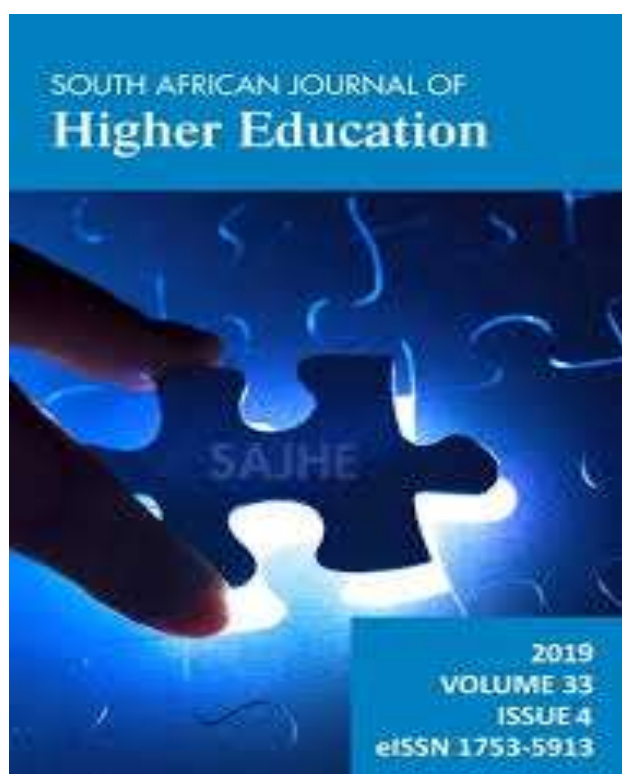
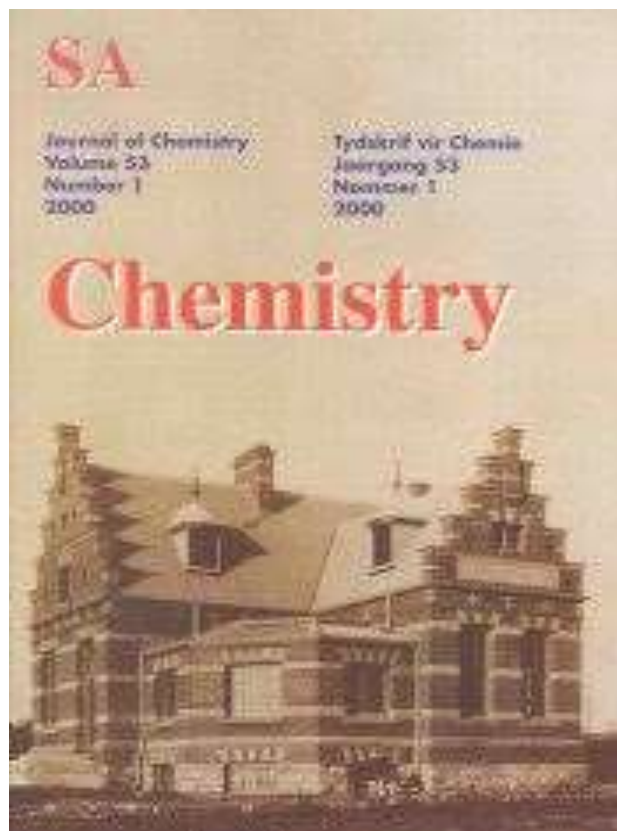
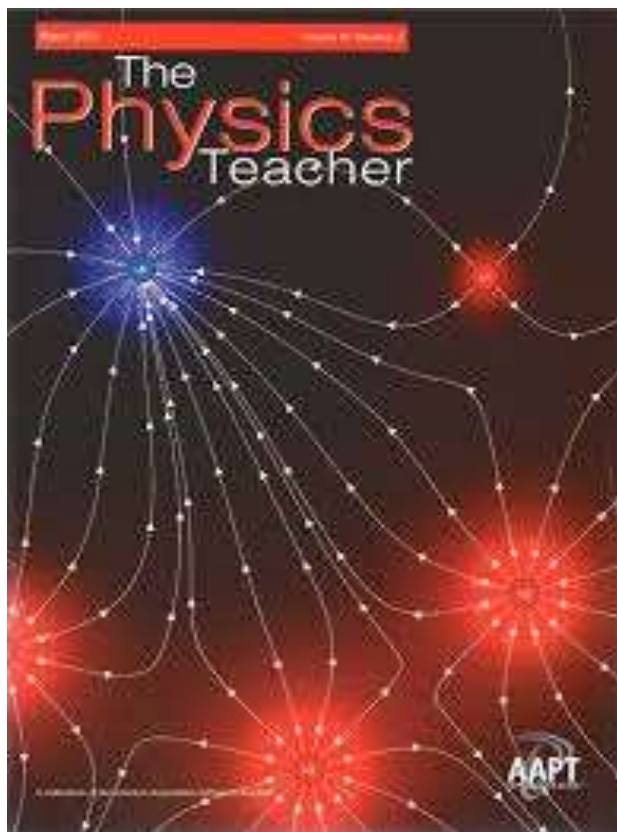


Peer Reviewed Academic Articles

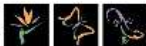
Other than those in the Journal of Chemical Education
which are all in a separate file.

by Gavin D Peckham



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African Biodiversity & Conservation



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My First Research Publication – and How I was Cheated Out of It

Caerphilly, Wales. February 2026

For much of 1976 the University of Zululand was closed due to student unrest. Hence I was able to undertake my first research since graduating – having spent almost two years teaching at Northlands Boys' High School in Durban before being appointed to the lecturing staff of UniZul in September 1975.

The head of department, Prof Gert Lamprecht, had previously set up equipment to study the densities and other properties of assorted molten salt mixtures but had not got around to actually getting any research done. The 1976 student riots and partial closure of UniZul gave us the necessary time to rectify the matter and get some molten salt research done. Whilst Gert gave guidance, I personally carried out virtually every single bit of the experimental work myself – as well as doing all the requests for relevant literature from other researchers around the world – a process that was done by letter in those days.

Gert said that he would write up the paper and submit it to an accredited journal. Months passed and Gert repeatedly fobbed off my enquiries about the progress of the article. Then I discovered, through the grapevine, that it had already been published. I confronted Gert and asked him for a copy after much ducking and diving, he eventually gave me a copy. Because of his evasive attitude I already suspected that no everything was above board, and on seeing the article I realised why he had been so evasive. He had published the article as the sole author without even an acknowledgement to the work I had done. I was speechless but, as a newly appointed junior member of staff, I powerless to do anything about it.

Time passed, Gert moved to Bloemfontein University and I applied for promotion. To boost my chances, I wanted to add that publication to my application so I wrote to Gert, explained the situation, said that much water had passed under the bridge and asked if he would he do me the favour of writing a letter an official letterhead acknowledging that my name had been left off the article “by accident”. To my amazement he did this – probably driven by a guilty conscience – and my subsequent application for promotion was successful.

However, I also sent a copy of the letter to the Journal editor and asked if the correction to the authorship could be printed as an “erratum”. The editor, to his credit, first checked the facts with Gert – by mail of course – who was kind enough to confirm the facts, and an Erratum was subsequently published.

Then, fifty years later, while searching the internet, trying to find a copy of this article online, I discovered that Gert had actually published a second paper, on a different aspect of the same molten salt system, but still based entirely on my experimental work. In this paper he needed the assistance of a colleague from the Maths Department. Carl was much less naïve than me and had insisted on co-authorship, whilst I was yet again left out in the cold.

Now, in my dotage, I am trying to collect my assorted writings and have searched online for copies of the original article, the erratum and the second article which my search for the first had uncovered.

I have been able to recover the first pages of the two articles but have been unable to find the erratum which was simply a short paragraph and may not have been independently digitised.

The first pages of the two articles mentioned above are attached below and should both carry my name as a coauthor. [Back to Contents](#)

Densities of the Molten Salt System CsBr-CuBr

Journal of Chemical and Engineering Data, 1977, 22(3), pp 329-330

Densities of the Molten Salt System Cesium Bromide–Cuprous Bromide

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Densities of the molten salt system cesium bromide–cuprous bromide have been measured at nine mole fractions over the complete composition range and in the temperature range 507–950 °C using the method of Archimedeian displacement. The temperature coefficients of the densities have been evaluated from these measurements.

The present work was undertaken as part of a research project of the above mentioned department on the properties of molten cuprous halide–alkali halide systems.

Experimental Section

Materials. Cesium bromide (Merck/Suprapur) was dried under dynamic vacuum at 300 °C for 24 h and used without further purification. Cuprous bromide (Riedel-de Haën, 99 %) was further purified (4, 5) by dissolving it in the minimum amount of 47 % hydrobromic acid (Merck/Suprapur) and reprecipitating by dilution with deaerated distilled water containing 1 g of anhydrous sodium sulfite per liter. The white precipitate was washed successively with water (as described for the dilution process) and acetone and then vacuum dried as specified for the cesium bromide. To minimize oxidation of the purified cuprous bromide during subsequent handling it was melted under vacuum and formed a light green crystalline substance upon cooling. All storage and handling of the purified salts took place under an atmosphere of nitrogen, purified and dried by passing it through

columns containing silica gel (Merck) and Type 5A molecular sieve (BDH Chemicals Limited).

Apparatus and Procedure. The furnace, balance, sample assembly, and experimental procedure were similar to those described by Brookes and Paul (1), except for the following respects.

The nichrome suspension wire hanging from the stirrup of the balance to the sinker (bob) went through a short length (2 cm) of a Silicone rubber tube attached to the top of the Pyrex tube enclosing the suspension wire. The Silicone tube could be clamped vacuum tight which enabled the system to be evacuated or kept under a completely closed inert atmosphere. During the short time an actual mass measurement was conducted the clamp on the Silicone tube was released and dry purified nitrogen escaped through the Silicone tube to the atmosphere. The nitrogen was released at a fixed pressure during each mass measurement to ensure a constant upthrust by the gas on the suspension wire. Prior to each mass measurement the system was subjected to a vacuum to remove possible nitrogen bubbles from the sinker.

The relatively high vapor pressure of cuprous bromide (3) leads to condensation on the suspension wire. To correct for the condensation the wetting of the sinker, after immersion in a molten salt mixture, was determined at the beginning of each run before condensation occurred on the suspension wire. The wetting of the sinker as a function of temperature at a given mole fraction was determined by duplicate runs beginning at various temperatures. Once the wetting of the sinker was known it was possible to make a correction for the condensation on the sus-

Thermodynamic Properties of the Molten Salt System CsBr-CuBr

Journal of Chemical and Engineering Data, 25(2), 1980, pp 110-113

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J. Chem. Eng. Data 1980, 25, 110-113

Table IV. Average Deviations between the Predicted and Experimental Values by the Bubble Point Prediction

pressure, mmHg	$\lambda_{12} - \lambda_{11},$ $\lambda_{21} - \lambda_{22}$ at each pressure		$\lambda_{12} - \lambda_{11},$ $\lambda_{21} - \lambda_{22}$ of 1 atm pressure		$\lambda_{12}, \lambda_{21}$ of 1 atm pressure	
	Δy_1^a	ΔT^b	Δy_1^a	ΔT^b	Δy_1^a	ΔT^b
760.0	0.003	0.2	0.003	0.2	0.003	0.2
400.0	0.004	0.1	0.005	0.3	0.006	0.4
200.0	0.005	0.1	0.006	0.3	0.008	0.5
100.0	0.006	0.1	0.004	0.4	0.007	0.6
50.0	0.005	0.2	0.005	0.4	0.010	0.7

^a $\Delta y_1 = \sum y_{1, \text{calcd}} - y_{1, \text{exptl}} / n$. ^b $\Delta T = \sum |t_{\text{calcd}} - t_{\text{exptl}}| / n$.
 n = number of data.

Glossary

g^E	molar excess Gibbs energy, cal/mol
P	total pressure, mmHg
p_i	vapor pressure of pure substance i , mmHg
Q	Q function ($= g^E / RT = x_1 \ln \gamma_1 + x_2 \ln \gamma_2$)
R	gas constant, cal/(mol K)
T, t	temperature, K, °C
v_i	molar liquid volume of pure i at temperature T , cm ³ /mol

x_i, y_i mole fraction composition of component i in the liquid and vapor phases

Greek Letters

γ_i	i component activity coefficient of liquid phase
$\Lambda_{12}, \Lambda_{21}$	Wilson parameters defined by eq 2
$\lambda_{12} - \lambda_{11},$ $\lambda_{21} - \lambda_{22}$	Wilson parameters, cal/mol

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Thermodynamic Properties of the Molten Salt System Cesium Bromide-Cuprous Bromide

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Molar volumes, excess molar volumes, partial molar volumes, and molar volume expansion coefficients were calculated for the binary molten salt system cesium bromide-cuprous bromide.

The experimental procedures and density results obtained in the system cesium bromide-cuprous bromide have been described previously (6). The temperature coefficients of the densities were evaluated at nine mole fractions over the complete composition range and in the temperature range 507-950 °C, using the method of Archimedean displacement.

This paper reports on the calculation of molar volumes, excess molar volumes, partial molar volumes, and molar volume expansion coefficients in the system cesium bromide-cuprous bromide.

Density and Temperature Coefficients of the Density

The experimental density data (6) were fitted to equations of the form

$$\rho = a - bT \quad (1)$$

where ρ is in grams per cubic centimeter and T in Kelvin, and are listed in Table I. Figure 1 gives an overview of the densities, calculated from the data in Table I, over the entire composition range at three chosen temperatures.

Table I. Least-Squares Fits for the Densities Fitted to Equation 1

mole % of CsBr	$a, \text{g cm}^{-3}$	$10^3 b, \text{g cm}^{-3} \text{K}^{-1}$	std dev	temp range, K
100.000	4.244 ₉	1.223	a	a
85.097	4.283 ₄	1.323	0.0019	918-1226
74.239	4.451 ₀	1.326	0.0020	880-1223
58.763	4.586 ₄	1.377	0.0028	870-1222
40.543	4.617 ₃	1.231	0.0021	850-1226
30.000	4.932 ₂	1.400	0.0027	861-1223
19.961	5.021 ₇	1.300	0.0035	849-1227
10.467	5.085 ₈	1.141	0.0058	840-1224
0.000 ^b	5.282 ₈	0.916	0.0067	780-1224

^a See ref 4. ^b Pure CuBr.

Molar Volumes and Excess Molar Volumes

Calculated values for molar volumes, standard deviations in molar volumes, ideal molar volumes, and excess molar volumes at three chosen temperatures are listed in Table II. Molar volumes V_M , ideal molar volumes V_I , and excess molar volumes V_E were calculated from the equations

$$V_M = (1/\rho) \sum x_i M_i \quad (2)$$

$$V_I = \sum (x_i M_i / \rho_i) \quad (3)$$

$$V_E = (1/\rho) \sum x_i M_i - \sum (x_i M_i / \rho_i) \quad (4)$$

A Generalised Equation for Calculating pH

South African Journal of Chemistry, 38(3), 1985, pp 152-153

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S. Afr. J. Chem., 1985, 38(3)

Of note is the lack of any significant regioselectivity observed when diene (2) was reacted with toluquinone, 2-methoxybenzoquinone, and 5-chlorotoluquinone. This suggests that the degree of electronic dissymmetry proposed for diene (2) is not sufficient to recognize these dissymmetric dienophiles.¹⁵ By extension, this situation applies to the monoacetal dienophiles, and the regioselectivity observed must arise primarily from steric factors. To test this premise, the more bulky diethyl acetal analogue of 6a was prepared and reacted with 2. This cycloaddition product, on investigation with shift reagent,¹³ showed only a single regioisomer to be present. The corresponding sequences with the diethyl analogues of 6b and 6c again showed reduced regioselectivity relative to that of the unsubstituted parent monoacetal. In the case of the diethyl (6c) analogue, a product (8:9) ratio of 1:2.6 is observed; this is a distinct improvement over that achieved for the dimethyl monoacetal (6c). On the other hand, the alternative diethyl (6b) analogue led to a surprising loss of regioselectivity, reflected by a product (8:9) ratio of 1.2:1.

Studies to ascertain whether this regioselectivity may be improved on in the case of naphthalene moieties, suitable for anthracenone synthesis, are at present underway.

Acknowledgements

We thank the South African Council for Scientific and Industrial Research and the Natal University Research Fund for financial support, and Mr. M. Watson for performing the ¹H n.m.r. ratio determinations.

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A generalized equation for calculating pH

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Dedicated to the University of Natal
on the occasion of its 75th Anniversary

A generalized equation is derived for the calculation of pH.

'n Veralgemeende vergelyking vir die berekening van pH word afgelei.

This note presents an equation which can be used to accurately calculate the pH of a wide range of aqueous systems. A restricted version of this equation has already appeared in the literature.¹ The restricted equation applies directly to the very common situation where the most protonated species is uncharged. Several important classes of compound, e.g. amino acids and polyamines, cannot be directly treated with that equation, whereas the equation given below can handle these cases without artifice.

Let the solution contain a weak acid which, in its most protonated form, can be written as $H_m A^{n+}$ at an analytical concentration c . It is a straightforward application of mass and charge balance relationships to show that the concentration of the hydrogen ions obeys the equation,

$$\frac{K_w}{[H^+]} - [H^+] + c\theta + N_s = 0 \quad (1)$$

where K_w is the ionic product of water, N_s the normality of any added strong acid (N_s positive) or strong base (N_s negative) and

$$\theta = \frac{\left| \frac{(n-1) \prod_{i=1}^{n-1} K_i}{1 + \sum_{i=1}^n \prod_{j=1}^i \frac{K_j}{[H^+]}} \right|}{\left| \frac{(n-1) \prod_{i=1}^{n-1} K_i}{1 + \sum_{i=1}^n \prod_{j=1}^i \frac{K_j}{[H^+]}} \right|} \quad (2)$$

K_i in eqn. (2) is defined by the equilibrium



$$K_i = \frac{[H^+][H_{m-i} A^{(n-i-1)+}]}{[H_{m-i+1} A^{(n-i)+}]}$$

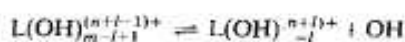
If there are k weak acids then eqn. (1) becomes

$$\frac{K_a}{[H^+]} - [H^+] + \sum_{i=1}^k c_i \theta_i + N_s = 0 \quad (3)$$

where c_i is the analytical concentration of acid i . For a weak base, $L(OH)_m^{n+}$, eqn. (2) is replaced by

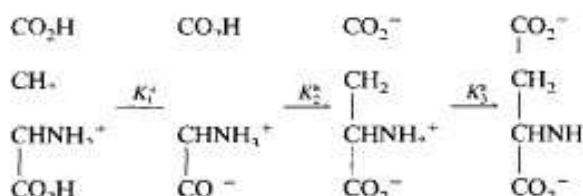
$$\frac{-\left\{n + \sum_{j=1}^n \left[(n+j) \prod_{i=1}^j \frac{K_i^b}{[OH^-]} \right] \right\}}{1 + \sum_{j=1}^n \prod_{i=1}^j \frac{K_i^b}{[OH^-]}} \quad (4)$$

K_i^b in eqn. (4) is defined by the equilibrium



It should be noted that, in the case of an acid, n refers to the charge on the *most* protonated species while, for a base, n refers to the charge (including sign) on the *least* protonated species. The essential difference between eqn. (2) and the equation given by Clare¹ is the explicit recognition of the charge on the parent species: it is this feature which makes these equations directly applicable to a wider class of compounds.

Eqns. (1), (2), and (4) permit the ready calculation of the pH of any combination of acids, bases, salts, and ampholytes, as well as the generation of titration curves. Consider aspartic acid as an example:



This can be treated as H_3A^+ , i.e. $m = 3$, $n = 1$. Eqn. (2) gives

$$\frac{1 - \frac{K_1^+ K_2^+}{[H^+]} - 2 \frac{K_1^+ K_2^+ K_3^-}{[H^+]^3}}{1 + \frac{K_1^+}{[H^+]} + \frac{K_1^+ K_2^+}{[H^+]^2} + \frac{K_1^+ K_2^+ K_3^-}{[H^+]^3}}$$

The ease with which the exact equation can be written down, and the ready availability of microcomputers which can quickly solve the resulting equation should make redundant the numerous approximate equations which appear in the literature.² In particular, the difficult choices between the various approximate formulae for ampholytes^{3,4} and the numerous special cases for salts of various types⁵ entirely disappear with one general equation applying exactly to all situations. Eqns. (2) and (4) are used to generate the expressions for θ , which apply to the acids and bases from which the salt is made, and then eqn. (3) is solved with the appropriate expressions for θ substituted.

Numerical solution of eqn. (3) by the Newton-Raphson method⁶ has proved unreliable; however, the bisection method⁷ has been consistently successful.

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The Use and Abuse of Significant Figures

Spectrum 24(3), 1986, pp 16-18

The use and abuse of significant figures

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Introduction

Having surveyed a number of physical science textbooks in current use in South African secondary schools we have found that scant attention is paid to the correct use of significant figures. Answers to both worked examples and sample problems are often given with an accuracy far in excess of that which is appropriate for the given data. Similar disregard for the correct use of significant figures is apparent in recent NSC matric papers, and the current syllabus gives no guidelines in this respect. It is no wonder, therefore, that pupils tend to produce answers to calculations which are limited only by their calculator's display or by the width of their paper! Satek⁽¹⁾ presents a useful exercise which may be effectively used to demonstrate this point to pupils.

Pupils should be encouraged to develop a 'feel' for the correct use of significant figures in their calculations, and the purpose of this article is to give some guidelines on the handling of significant figures. The prescription approach to the correct use of significant figures has its dangers in that the blind application of a set of rules may not accommodate the subtleties of a particular situation. This is illustrated by the different significance attached by, say, an accountant and a statistician to a set of data⁽²⁾. They may both have to deal with the same set of numbers, but, whereas the accountant must of necessity keep a check of every cent, the statistician may be quite justified in rounding off the data to the nearest hundred, or nearest thousand rands. Bearing this in mind, let us take a brief look at the origin, nature and applications of significant figures.



"Now, there's a collection of significant figures for you!"

The origin of significant figures

Most numbers used in calculations have their origin in a physical measurement. All physical measurements are to some degree inaccurate because of inherent errors in the construction and calibration of the measuring instrument. In addition, there is an uncertainty involved in the

experimentalist's ability to read the instrument exactly. Results of an experiment should never be given to such a precision as to exceed the standard error. We shall not, at this level, discuss the theory of errors nor define the term 'standard error'. Suffice it to say that the standard error is a means of determining the number of significant figures to be specified in a result. As a rule of thumb the significant figures in a measured quantity are those which we can be certain to be correct, plus one last figure which may be regarded as an uncertain estimate. For example, a voltmeter reading from 0V to 3V in 0,1V intervals can be read accurately to within 0,1V, but the next decimal place must be estimated. Thus, readings taken on such a device are not significant beyond the second decimal place.

eg 2,43V (2 decimal places and 3 significant figures)

0,88V (2 decimal places and 2 significant figures)

0,05V (2 decimal places and 1 significant figure)

Although this voltmeter cannot give a reading which is reliable beyond the second decimal place, the actual number of significant figures quoted may vary from one reading to another.

Identification of significant figures

A pupil carrying out a textbook calculation has not taken the data readings himself and may thus be unaware of the significance which should be attached to such numbers. Various methods may be used to identify the significant figures in such cases.

The conventional approach

Rules: (i) All non-zero digits (NZD) and zeros between NZD are significant.

eg 174,35 has five significant figures

10,709 has five significant figures

(ii) All zeros which follow a decimal comma and lie to the right-hand side of NZD are significant.

eg 7,200 has four significant figures

20,060 has five significant figures

(iii) Zeros which are used only to indicate the position of the decimal comma are not significant.

eg 0,0904 has three significant figures

0,904 has three significant figures

9 040 has three significant figures

90 400 has three significant figures

Note that the position of the decimal comma has no effect on the number of significant figures.

The arrow method⁽³⁾

Rules: (i) If the number contains a decimal comma, draw an arrow from the left-hand side until you come to the first NZD. All the remaining digits are significant.

- eg $\rightarrow$ 7040,0 has five significant figures
 $\rightarrow$ 0,007040 has four significant figures
- (ii) If the number does not contain a decimal comma, draw an arrow from the right-hand side until you come to the first NZD. All the remaining digits are significant.
 eg 70 400 $\leftarrow$ has three significant figures.

The problem of zeros⁽⁴⁾

If a number such as 120 000 has been measured correct to the nearest unit, and purely, by chance, happens to end in zeros, then the zeros are significant and may be indicated as such in one of three ways, namely (i) by the use of exponential notation^(5,6), (ii) by the use of the bar⁽⁶⁾, (iii) by stating the *uncertainty*^(7,8).

eg Suppose 120 000 has been measured correct to the nearest unit, we could indicate this by

- (i) $1,200\ 00 \times 10^5$ (six significant figures)
 (ii) $\overline{120\ 000}$ (six significant figures)
 (iii) $120\ 000 \pm 0,5$ (six significant figures).

Measured correct to the nearest thousand, this number would be expressed as

- (i) $1,20 \times 10^5$ (three significant figures)
 (ii) $\overline{120\ 000}$ (three significant figures)
 (iii) $120\ 000 \pm 500$ (three significant figures).



"Now, that's what I call a significant figure."

The application of significant figures in calculations

A guiding principle here is that there is some limit to the number of significant figures which may be given meaningfully in the answer to a calculation. Some particular cases are given below:

Addition and subtraction

When adding or subtracting numbers, the answer should be rounded off, so as to retain digits only as far as the first column containing an estimated figure.

eg (i) $\begin{array}{r} 425,1 \\ + 93,529 \\ \hline 518,629 \end{array}$ Ans 518,6	(ii) $\begin{array}{r} 20700 \\ - 1562,6 \\ \hline 19137,4 \end{array}$ Ans 19100
---	---

(iii) $27 + 1,48 \times 10^{-3} - 1,49 + 12,0 - 0,0475 = 37,46398$

Ans 37.

Multiplication and division

When multiplying or dividing numbers the answer should be rounded off to the same number of significant figures as there are in the least exact factor.

eg (i) $28,231 \times 1,28 = 36,135\ 68$ Ans 36,1
 (ii) $124,02 \div 9,4 = 13,193\ 61$ Ans 13

Logarithms (Base 10)⁽⁹⁾

(a) Taking logs. Record one more digit in the logarithm *mantissa* than there are significant figures in the number, eg $\log 7,25 \times 10^{13} = 13,86033801 \dots$ Ans 13,8603 (3 SF) (4 SF)

(b) Taking antilogs. Record one less digit in the number than there are significant figures in the *mantissa* of the logarithm. (The characteristic of the log plays no part.) eg $10^{-1,2571} = 0,055322271 \dots$ Ans 0,0553 (4 SF) (3 SF)

The main area in the current matric syllabus for which this guideline may be helpful, is in pH calculations.

Exact numbers

Exact numbers may be regarded as having an indefinite number of significant, trailing zeros, eg 12 men $\Rightarrow$ 12,000 000 ... men.

Exact numbers should thus never be used as the determining factor which limits the number of significant figures reported in a calculation.

eg 12 men have an average mass of 81,03 kg. Their total mass is 972,4 kg, not 970 kg.

Implied significant figures

The contents of a 250 cm³ volumetric flask, correctly filled, may be taken to have a volume of 250,0 cm³ (4 SF) and not 250 cm³ (2 SF). The use of the term 'correctly filled 250 cm³ volumetric flask' implies an accuracy greater than that given in the 250 cm³ label. This type of example may be regarded as a bit of grey area as far as the specification of significant figures is concerned, since it relies on the reader's insight into the nature of the quantity.

Carrying significant figures through a calculation⁽¹⁰⁾

Drawing a pupils attention to the irrelevance of long strings of digits may lead to the opposite extreme of exaggerated rounding off of numbers. Even correct rounding off of intermediate answers in a calculation may lead to a small discrepancy in the final answer if the above 'rules' are applied. It is thus sound policy to carry an excess of at least one significant figure through the various steps of a calculation and then to round off the final answer to the correct number of significant figures. If it is necessary to report some of the intermediate answers these should also be rounded off only after the calculation has been completed. At a more advanced level, this rather vague approach could be avoided by the rigorous application of the relevant error theory.

Rounding off numbers

Reference has been made in the preceding sections to the need to round off numbers. The following rules apply to the procedure:

- 1 If the digit following those to be retained is less than 5, the retained digits remain unaltered
- 2 If the digit following those to be retained is greater than 5, the last digit retained is increased by one
- 3 If the digit following those to be retained is exactly 5, the last digit retained is increased by 1 if it is odd, but remains unchanged if it is even.

Examples: Round the following numbers off to two decimal places:

Number	Answer	
24,534999	24,53	(Rule 1)
24,535001	24,54	(Rule 2)
24,535000	24,54	(Rule 3)
24,525000	24,52	(Rule 3)

In the days of the slide rule the problem of significant figures was largely solved by the slide rule itself^(10,11). However, the era of the electronic calculator suggests that there is a need to reassess this problem and one feels an approach along the lines presented above would be of benefit to pupils studying physical science.

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If You Don't Have a Slicker Does It Pay to Walk Quicker

Science Teacher, Vol. 54, No. 9, Dec 1987, pp. 35-39

JOURNAL ARTICLE

If You Don't Have a Slicker, Does It Pay to Walk Quicker?

G. D. Peckham, M. J. Joubert and I. J. McNaught

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If You Don't Have a Slicker, Does It Pay to Walk Quicker?

by G. D. Peckham, M. J. Joubert, and I. J. McNaught

The physics of
staying
dry.

It's pouring rain outside. You're poised at the doorway, wondering—Is there some optimum running speed that will minimize the effects of the down-pour? Finding the answer can enliven your advanced physics class on a rainy Friday afternoon, quite aside from the practicality of figuring out how to stay driest.

The problem can be treated by considering a simple mathematical model. Depending on the time you have available and the capabilities of your students, the problem can be approached in a number of ways, each involving an increasingly sophisticated set of assumptions.

For the most elementary case, we can make the simplifying assumption that there is no wind and that the rain thus falls vertically with a terminal velocity of v meters per second. The intensity of the shower can be described as rainfall "density," ρ , expressed in kilograms of rain per cubic meter of space at any instant. The body onto which the rain falls can be separated into a horizontal surface of area A_H and a frontal vertical surface of area A_V , each expressed in square meters. Let's assume that the body covers a fixed distance of s meters in a time of t seconds at a constant velocity of V meters per second, at right angles to v , as shown in Figure 1 on page 37.

For any nonzero value of V , the rain will strike both the horizontal and vertical surfaces of the body. The amount of rain falling on the horizontal surface is proportional to the area of the surface, the rainfall density, the

time for which the surface is exposed to the rain, and the velocity with which the rain approaches the surface.

Thus the amount, or mass, of rain falling on the horizontal surface, M_H , is expressed as

$$M_H = A_H \rho v t \quad [1]$$

(For our purposes, all vector quantities used in equations are replaced by their magnitudes only.)

The amount of rain striking the front vertical surface is proportional to the area of the surface, the rainfall density, and the distance through which the surface moves. Thus, the mass of rain striking the vertical surface, M_V , is expressed as

$$M_V = A_V \rho s \quad [2]$$

The values of M_H and M_V as given in equations 1 and 2 are similar in that they both are proportional to the area and the rainfall density. However, there are two differences between the equations. First, M_H depends on the rainfall velocity, v , but M_V is independent of v . Second, if we assume that a fixed distance s must be covered, then equation 1 shows that M_H varies inversely with the body's velocity, V , since $t = s/V$. But M_V is independent of V , since the product Vt must be constant once s is fixed. The dependence of M_H and M_V on V for a given value of s is indicated in Figure 2, where M_T is the total mass of rain striking the body.

M_T is given by the sum of equations 1 and 2. That is,

Application of Maxwell-Boltzmann Distribution Diagrams to Evaporation

La Fisica Nella Scuola, Anno XXII n. 1, gennaio – marzo 1989

(La Fisica Nella Scuola, 22(1), January – March 1989, pp 27-34)

Un'applicazione dei diagrammi della distribuzione di Maxwell-Boltzmann al processo di evaporazione. G. Peckham, J. I. Mcnaught

<https://www.aif.it/indice-rivista/indice-rivista-anno-xxii-n1-gennaiomarzo-1989/>



This is all that's available online.

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New Botanical Perspectives on the *Raphia* Palms at Mtunzini

Bothalia, 19(2) 1989, pp 213-215

NEW BOTANICAL PERSPECTIVES ON THE ORIGIN OF THE *RAPHIA* PALMS AT MTUNZINI

The natural distribution of *raphia* palms in South Africa is limited to the Kosi Bay area in the extreme north-east of Zululand. However, early this century a grove of *raphia* palms was established at Mtunzini about 250 km further south on the Zululand coast (Figure 7).

There has been much speculation as to exactly when, why and how the first *raphia* palms were introduced to Mtunzini. Secondary sources, past and present, verbal and non-verbal, (Austen 1953; C.C. Foxon Jr pers. comm. 1987; Harrison 1986; Oberholster 1972; Palmer & Pitman 1972) differ somewhat with respect to the 'when' and 'why'.

The original supply of seed was in fact sent from Pretoria to Mtunzini by the then Secretary for Justice and Director of Prisons, Jacob de Villiers Roos (1916), who wrote to the magistrate at Mtunzini on the 21st July 1916, that it would be economical to grow the *raphia* palm in the marshy Government ground there, to supply the fibre for the Prison brush and broommaking industry, instead of importing it from West Africa via London.

This directive from Roos to C.C. Foxon, who was magistrate at Mtunzini from 1905 to 1921, clearly fixes the date and the reason for the establishment of *raphia* palms at Mtunzini. The origin of the seed supplied by Roos is not stated. However, on the 19th July 1916, A.M. Bottomley (1916) of the Division of Botany in Pretoria, wrote to Roos stating, 'I am forwarding you herewith the seed of *Rafia* (sic) *vinifera* which we obtained from Zululand'. It seems likely but not certain, that this was the seed, which, two days later, was forwarded to Foxon by Roos.

Two further parcels of *raphia* seed were sent to Foxon on behalf of the Director of Prisons, Pretoria, for planting.

The covering letter (Director of Prisons 1917a) for the second batch, dated 10th January 1917, gives no indication whatever of the source of the seed.

It may also have been Zululand or perhaps Portuguese East Africa, but it is not unreasonable to consider the possibility that the seeds may even have come from West Africa, since *raphia* produce was imported from that source on a regular basis.

However, the covering letter (Director of Prisons 1917b) for the third (and apparently final) batch, dated 20th January 1917 states, 'I am forwarding under separate cover a consignment of the abovementioned seed (*R. vinifera*) which has been received from Portuguese East Africa'. This batch may have been *R. australis*, a species described only in 1969 (see discussion below) or *R. vinifera*, both of which occur in what is today Mozambique.

It is clear that in no single instance can the identity of the original batches of seed be established beyond reasonable doubt. Obviously, at least one batch must have contained *R. australis* in order to account for the existence of the present population at Mtunzini. At the time it was believed that all these seeds were of the species *R. vinifera*, but this was to be disproved later, as we shall see.

The *raphia* palms indigenous to northern Zululand and southern Mozambique are geographically isolated from other giant *raphia* palms in Africa. Despite this they were originally presumed to be of the species *R. vinifera* which occurs commonly in West Africa. An indication to the contrary was recorded when specific differences between the fruits of the Kosi Bay palms and those of *R. vinifera*, were noted by Aitken & Gale (1921), who concluded that 'either



FIGURE 7.—*Raphia* palms at Mtunzini, Zululand coast.

this palm is a variety of *R. vinifera*, or it may be a new species of the genus. King (1925) also referred specifically to 'the true Raffia Palm', *R. vinifera*, and 'the giant palms from Kosi Bay', clearly believing them to be different species.

Much later, 1967, two palms at the Botanic Station in Durban, which were grown from seed collected at Mtunzini by Dr V.A. Wager, developed large (± 3 m), erect inflorescences growing centrally above the crown of the leaves. It was then realized that a previously undescribed species was involved since, amongst others, the inflorescence of *R. vinifera* is pendulous. Obermeyer & Strey (1969) described the new species and named it *R. australis*. Despite the inclusion of 'Historical Notes' in their paper, Obermeyer & Strey make no reference to the observations of Aitken & Gale and King, whose earlier reports appear to have been overlooked.

The very uncertain identity of the original seed and the proven ease with which the true identity of established raphias may be overlooked, suggest the strong possibility that one or even more raphia species other than *R. australis* were also introduced to Mtunzini. Further support for this possibility is contained in a letter addressed to the Conservator of Forests, Pietermaritzburg, by King (1925), who stated that, 'The seeds supplied by Mr de V. Roos were of the true Raffia Palm. In addition to these certain seed of the giant palms from Kosi Bay was planted'. Yet today only *R. australis* is known to grow in the Mtunzini area. It could be speculated that the exotic species died out because they were less well adapted to local conditions.

The increase of *Raphia* trees in the immediate vicinity of Mtunzini was facilitated in the 1940's by L.E. Davis who collected seeds from the original grove and planted them while visiting the surrounding swamplands in the course of his duties as malaria control officer (Palgrave 1977; Wicht 1969).

In 1942 the original grove was declared a national monument (Government Gazette 1942). The grove is of no great historic significance and the procedures which led to the declaration were somewhat unorthodox. In spite of this, Mtunzini's raphia palms joined about 17 other botanical specimens which form about 5% of the list of the country's official national monuments (Oberholster 1972). The grove at the original site was virtually destroyed in 1948 when a spark from a passing locomotive set the trees ablaze (Oberholster 1972). The remaining trees were able to regenerate and a fine grove of palms may be seen at the site today.

Over the last three decades Mr Ian Garland has made a substantial contribution to the population of raphia palms by planting and distributing almost a thousand *R. australis* on, and in the vicinity of his farm 'Twin Streams', which borders Mtunzini (I.F. Garland pers. comm. 1987).

In recent years the Mtunzini Town Board has played an active role in promoting the raphia palm (Figure 7), which along with the closely associated palm nut vulture, *Gypohierax angolensis*, has been incorporated into the official town emblem (Government Gazette 1981).

Even though it is doubtful whether the exact origin of Mtunzini's raphia palms will ever be known their present status is secure and improving.

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New historical perspectives on the Raphia Palm Monument at Mtunzini

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The raphia palms now growing at Mtunzini on the Zululand coast do not occur there naturally and current opinions regarding the origin of these palms are inaccurate. The palms were in fact established in 1916 from seed sent to the Mtunzini magistrate by the Director of Prisons in Pretoria, the object being to establish a local supply of fibre for the prison's broom-making industry. Commercial interest in the palms ended when it was found that the fibre from these palms was unsuited to that purpose. Nevertheless, the palms continued to flourish and in 1942, after a rather inadequate investigation, they were proclaimed a national monument, an action which is being reconsidered at present.

Die raffiapalms wat te Mtunzini aan die kus van Zoelocland voorkom, is nie inheems aan Mtunzini nie en teenswoordige menings aangaande hul oorsprong is onakkuraat. Die oorspronklike palmsaad is in 1916 deur die Direkteur van Gevangenis, Pretoria, aan die landdros te Mtunzini gestuur met die doel om 'n plaaslike bron van raffia-vesel vir die gevangenis se besemvervaardigingsnywerheid daar te stel. Kommersiële belangstelling in die palms is beëindig toe dit aan die lig gekom het dat die vesel ongeskik is vir die bogenoemde doel. Die palms het nietemin floreer en na 'n ietwat onvoldoende ondersoek is die palms in 1942 tot nasionale monument verklaar. 'n handeling wat vandag met reg bevraagteken word.

Introduction

The raphia palms growing at Mtunzini on the Zululand coast were declared a national monument in 1942 and have at different times been the centre of commercial, botanical and historical interest. Considerable misinformation has been disseminated about these palms and many interesting facts concerning them have remained obscure. This article seeks to redress the situation.

The botanical background

The palms now growing at Mtunzini are one of 15 species belonging to the genus *Raphia*, all but one of which occur in the tropical and subtropical areas of Africa. Only one species of this genus is indigenous to the Republic of South Africa where its natural distribution is limited to a small area around Kosi Bay in the extreme north east of Zululand. Although the existence of these palms was already known to botanists at the turn of the century, they were believed, until recently, to belong to the species *Raphia vinifera*. It was only as recently as 1969 that they were identified as a new species which was named *R. australis*.¹

R. australis has the distinction of carrying the longest leaves in the plant kingdom and whilst the tree may grow to a height of about 25 m, more than half of this may be attributed to the length of the vast arching leaves which may reach as high as 18 m. The palms are fast-growing but have a relatively short life span, averaging 20 to 30 years. They are monocarpic and die after producing a single batch of eight to ten thousand fruits on an enormous inflorescence which develops in the crown of the leaves.^{2,3} These fruits form part of the diet of the palm nut vulture, *Gypohierax angolensis*. This large raptor is rare in South Africa and its distribution is closely associated with that of the *R. australis*⁴ (Figures 1, 2, 3).

Establishment of the raphia palms at Mtunzini

Early this century a grove of raphia palms was established at Mtunzini, which is better known to historians as the administrative and judicial headquarters of John Dunn, a white hunter/trader who served as a chieftain



Figure 1 A young *R. australis* aged about five years.

Photo: F.A. van Jaarsveld.



Figure 2 Mature *R. australis* aged about 15 to 20 years.

Photo: F.A. van Jaarsveld.

under the Zulu King Cetshwayo and who exercised a considerable amount of political control in the area for almost half a century.⁵

Much has been written about the establishment of raphias at Mtunzini but little of this information which appears to be based on local folk lore is accurate.⁶ A typical account⁷ is that of Errol Harrison, a palm enthusiast resident in Zululand, who writes:

'The grove at Mtunzini was started by Mr C.C. Foxon who was the local magistrate at that time. Mr Foxon was a very keen game hunter. He often went on hunting expeditions and on one of these expeditions he went to Kosi Bay. It was while he was hunting there that he came across extensive groves of *Raphia* palms growing along the shores of Lake Amanzimnyana ... He collected seed and planted these in the swamps near the (Mtunzini railway) station.'

The authors of authoritative botanical⁸ and historical⁹ texts give accounts similar to that of Harrison and further support for this narrative was obtained from C.C. Foxon (jnr.)¹⁰ whom the authors were privileged to interview shortly before his death in 1987. According to Foxon his father collected the seeds at Kosi Bay during a hunting trip in 1907. Foxon, who was born in 1916, could give no specific reasons for his father's decision to plant the palms at Mtunzini but was quite emphatic that these events took place in 1907.

Despite the claim of C.C. Foxon (jnr.), several other dates have been reported. A local official, L.E. Davis, claimed¹¹ that the raphias had already been growing for about five years when he arrived at Mtunzini in 1918, thus setting the date of establishment at about 1913. In contrast to these estimates, Harrison¹² and a Natal Parks, Game and Preservation Board ranger, W.M. Austen,¹³ both claim that the raphias were established at Mtunzini in 1915. Although there is a lack of unanimity



Figure 3 *R. australis* which have set seed, aged about 20 to 25 years. Notice the enormous inflorescences which project from the crown of each tree.

Photo: F.A. van Jaarsveld.

regarding the date, each of the above (refs. 6 to 13) concur in giving credit to C.C. Foxon (snr.), magistrate at Mtunzini from 1905 to 1921, for bringing the original seed to Mtunzini from the Kosi Bay area. However, neither the contention regarding the role played by Foxon (snr.), nor the alleged dates of establishment are correct.

The basic facts surrounding the origin of the raphia palms at Mtunzini are clearly spelled out in a letter¹⁴ sent from the Secretary for Justice and Director of Prisons, Jacob de Villiers Roos, to the magistrate at Mtunzini, C.C. Foxon (snr.), on 21 July 1916. The letter reads as follows:

'In the Prison brush and broommaking industry large quantities of bass fibre are used. This fibre is derived from the palm with the above name which flourishes in Portuguese Territory and to some extent also in Ingwavuma. At present this fibre is imported from West Africa via London at a very high cost. It would therefore effect a great saving if we could acclimatise the palm in the Union. It is understood that there is marshy Government ground in the neighbourhood of your Magistracy. The Minister would be glad if you would experiment in planting the seeds which go with this letter in the ground in question, using prison labour for the purpose. I shall be glad if you will take up the matter at once and report the progress from time to time.'

This directive from Roos to Foxon clearly fixes the date and the reason for the establishment of raphia palms at Mtunzini, but makes no reference to the origin of the seed supplied by Roos. However, on 19 July 1916 A.M. Bottomley of the Division of Botany in Pretoria, had sent Roos a parcel of raphia seeds obtained from Zululand.¹⁵ It seems likely but not certain that this was the seed which was forwarded to Foxon by Roos, two days later. Two further parcels of raphia seed were sent to Foxon on behalf of the Director of Prisons, Pretoria. The covering letter for the second batch¹⁶ gives no indication whatever of the source of the seed, but the covering letter for the third (and apparently final) batch¹⁷ states that the seed had been received from Portuguese East Africa. Even in this case it is not clear whether the seeds were grown in Portuguese East Africa or were imported via that country along with raphia fibre from West Africa. The lack of clear evidence regarding the origin of the seeds casts some doubt on the exact species planted at Mtunzini. This becomes a botanical rather than historical issue and the matter has been dealt with elsewhere.¹⁸

It is worth mentioning that Mtunzini was only one of several places at which it was suggested that raphias could be established for the purpose of providing a local supply of raphia fibre. The Experimental Farm at Winklespruit on the Natal south coast was suggested,¹⁹ whilst a small number of seeds were sent to both Umhlathuzi and to Empangeni, but the seeds failed to germinate and nothing further came of these ventures.²⁰ However, the Chief Native Commissioner for Natal,

C.A. Wheelwright, responding to a query from Roos, suggested that both Mtunzini and the Amanzimtoti Mission Reserve south of Durban would be appropriate sites for experimentation with the planting of raphia palms.²¹ Wheelwright pointed out that the existence of suitable swampy ground adjacent to a railway line and the availability of prison labour would make Mtunzini an ideal location to establish the raphias.

Roos responded promptly to these suggestions and forthwith sent seed to the magistrate at Mtunzini as indicated above. At the same time batches of seed were also sent to Wheelwright^{22,23} who was directed to pass them on to the Amanzimtoti Mission. In addition to these seeds Wheelwright also had two dozen young palms sent to the Mission^{24,25} by E.W. Baxter, then the Magistrate at Ingwavuma, which incorporates the Kosi Bay region. The palms at the Amanzimtoti Mission were placed under the care of the American missionary Rev. F.R. Bunker.²⁶ We have been unable to locate any further information regarding their fate and a recent *in situ* search produced no evidence for their survival.

The progress of the raphia palms at Mtunzini

In contrast to the uncertain fate of the raphias at the Amanzimtoti Mission, the progress of those at Mtunzini is well documented. On 3 August 1916 Foxon reported to Roos that the first batch of seeds had been planted.²⁷ Foxon's subsequent reports^{28,29} expressed concern at the fact that the seeds had not germinated, but by 12 February 1917, he was able to report that the first two seeds had sprouted,³⁰ and by 3 January 1918 a total of 14 plants were growing.³¹ It is clear from this correspondence that there is no sound basis for the various claims that Foxon (snr.) had already established raphia palms at Mtunzini under his own aegis prior to 1916. Had this been the case he would most certainly have mentioned the fact in his correspondence with Roos. Instead, he claims³² only that 'I was the first to report on this palm when (I was) Magistrate of the Maputa Division (which incorporated Kosi Bay).'

Within a year of the first seeds being planted at Mtunzini, Wheelwright had a sample of raphia leaves sent from the Kosi Bay area to the Director of Prisons in Pretoria.³³ These leaves were examined at the Pretoria Central Prison and it was found that the fibre was too short to be of use in brush-making.³⁴ This verdict appears to have put paid to the original motivation for the establishment of the raphias at Mtunzini and interest in the palms seems to have shifted from the Department of Prisons to the Department of Forestry. Therefore, by 1925, forester T.S. Bertram was able to submit a detailed report³⁵ to District Forest Officer R.C. Kotze in which he noted, *inter alia*, that 46 of the seeds were now growing.

The palms continued to flourish and in 1942 were proclaimed a national monument — a matter which is dealt with in greater detail below. By 1944, in reply to a query from the secretary of the Historical Monuments Commission, the magistrate at Mtunzini reported³⁶ that the palms had begun to set seed towards the end of 1943

and would soon all be dead. He reported further that steps had been taken to plant seeds throughout the district. The distribution of these seeds in the immediate vicinity of Mtunzini was facilitated by L. E. Davis, a local official employed in malaria control. Davis collected seeds from the original grove and planted them whilst visiting the surrounding swamplands in the course of his duties.^{37,38,39} In 1948 the grove at the original site was virtually destroyed by fire when a spark from a passing locomotive set the trees ablaze.⁴⁰ Fortunately they were able to regenerate and a fine grove of palms may be seen at the site today.

Over the last three decades Ian Garland, a well-known local conservationist, has made a substantial contribution to the raphia population by planting and distributing almost a thousand *R. australis* on and around his farm, 'Twin Streams', which borders Mtunzini.⁴¹ In recent years the local Town Board has played an active role in promoting the raphia palm, which along with the closely associated palm nut vulture, has been incorporated into the official town emblem⁴² (Figure 4). In 1986 a



Figure 4 The official town emblem of Mtunzini, which incorporates stylized representations of the palm nut vulture and of *R. australis*. Photo: F. A. van Jaarsveld.

boardwalk was constructed over the swamp at the site of the original grove to facilitate viewing of the palms to interested persons (Figure 5). The Town Board has propagated the trees widely on municipal land and has made the trees available free of charge to local residents for their gardens. As a result of these efforts, the palm currently enjoys a secure status.

Proclamation as a national monument

The proclamation of the raphias at Mtunzini as a national monument came about almost by chance. A well-known collector of Africana from Durban, Miss Killie Campbell, wrote to the Secretary of the Historic Monuments Commission.⁴³ This letter, dated 6 June 1942, instigated a process which eventually led to the proclamation and reads as follows:

'Raffia Palms: Mtunzini

Dear Sir,

Mrs W.K. Robertson, one of the leading lights of the Horticultural Society here, writes that about 600 to 700 yards the other side of Mtunzini is a clump of Raffia palms which is supposed to be "one of the Botanical wonders of Natal and Zululand" — and "that it is stated to be well worth preserving".

Miss Campbell continued,

'It is because it is so freely used by the natives there is a doubt whether it is still standing in its original form. Two men have approached Mrs Robertson and he (sic) promised to get in touch with me. Would it be possible to ask the Magistrate at Mtunzini, Zululand, to give us information about this clump of palms. Many of us are getting distressed to see the wanton destruction of some of our fine bush trees. I feel if we only make one example of preserving some outstanding tree or trees — it would show that we are alive to the fact that these trees (or flora) should be saved for the coming generation.'

This well-intentioned letter is both vague and inaccurate in that the palms at Mtunzini were at no stage 'free



Figure 5 The boardwalk which runs through the Raphia Monument at Mtunzini. Photo: F. A. van Jaarsveld.

used by the natives' and, furthermore, a good many outstanding trees had already been declared national monuments. For example the famous 'Post Office Tree' at Mossel Bay, proclaimed in 1938,⁴⁴ is of far greater historical interest than Mtunzini's raphias and the Mkambati Palms at Lusikisiki, proclaimed in 1936,⁴⁵ are of far greater botanical interest.

In response to Miss Campbell's letter, the Secretary of the Commission wrote to the Magistrate at Mtunzini asking for a report on the palms.⁴⁶ The magistrate in turn obtained a report from a local official, L.E. Davis, who expressed an unmotivated opinion that the palms should be proclaimed a monument in terms of the relevant act.⁴⁷ This opinion was passed on to the Commission and on 21 December 1942 the original grove of raphias was proclaimed a national monument⁴⁸ (Figure 6). One may mention in passing that the proclamation incorrectly indicated that the raphias were located in the Cape Province. A considerable amount of correspondence was required before this minor technical error could be corrected. A valid proclamation finally appeared in 1943, and so it was that Mtunzini's raphia palms joined a select group of about 17 other botanical specimens which form about 5% of the country's national monuments.⁴⁹ Bearing in mind the fact that the palms were proclaimed in terms of the Natural and Historical Monuments Relics and Antiquities Act of 1934, one may question the desirability of this proclamation since the palms are neither relics nor antiques and are of no great significance from either a natural or a historical point of view.

Since this time the legislation pertaining to national monuments has been changed⁵⁰ and under current statutes there is virtually no possibility that the palms would qualify as a national monument.⁵¹ On the basis of these observations the authors have recommended⁵² to the National Monuments Council that the raphia palms at Mtunzini be deproclaimed as a national monument, and have suggested that proclamation of the area as a nature reserve may be more appropriate. Be that as it

may, these impressive trees will continue to attract the attention and admiration of all those privileged to view them.

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Figure 6 The grove of *R. australis*, adjacent to the railway-line at Mtunzini, which currently enjoys the status of a historical monument. Photo: F.A. van Jaarsveld.

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teachers, doctors and trained workforce that it can produce. To produce the best graduates, we need to select the best students – irrespective of 'race'; and this requires that bursaries should be awarded on two criteria: academic merit and financial need.

It is obvious that great injustices were done to 'blacks' under the apartheid policies of the previous government, and it will take years to rectify the many disadvantages in our 'black' communities. I am in favour of 'affirmative action' if it means building more schools, hiring more teachers, providing clean water and sewage treatment, building more hospitals, and creating more jobs in our 'black' communities. But if 'affirmative action' becomes a euphemism for racist governmental policies of awarding jobs, bursaries, contracts, etc., it will only perpetuate the divisive injustices of a new apartheid.

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New-style Ph.D.s for the 'new South Africa'?

Sir, – The nature, approach and requirements for a Ph.D. degree at South African universities have changed little over the years, so there is perhaps a need to look at this situation in terms of changes which are occurring elsewhere.

Everett and DeLoach^{1,2} have outlined the historical development of the Ph.D. in the US, and Halstead³ has compared these requirements with those in Britain and Europe. In virtually all these cases the basis for the awarding of the degree is the presentation of original research results in the form of a thesis.

A ground swell of opinion has been rising against this traditional approach to the Ph.D. Emeritus Professor Max Hamilton of Leeds University states⁴ that, 'the [Ph.D.] system is extremely unsatisfactory and needs much new thinking.' In reporting on a conference on Ph.D. education, organized by the American Chemical Society, Beak⁵ poses the question of 'whether the past provides the optimal pattern for the future?' Contributors to the conference clearly thought not, and an even more specific attack on the *status quo* comes from Beverly Halstead, reader at the University of Reading, who expresses the opinion that 'the Ph.D. has become an ever expanding, multi-volumed monster with a life of its own.' Dixon⁶ agrees and condemns 'doctoral theses, prefaced by immense literature surveys, weighed down

by descriptions of methods that can be found in the relevant handbooks, and recording the minutiae of three years' effort, that can still be found accumulating, unconsulted, on university library shelves.' He goes on to say, 'Refusing a doctorate to a competent candidate with an impressive clutch of papers to his or her credit is as absurd as giving the degree to another student brandishing a fat tome whose contents are both unpublished and unpublishable.'

Halstead⁹ cites several cases of universities in the US which now include the publication of research material as an essential, or even sole, criterion for the awarding of a Ph.D. and he hints at a major potential pitfall with the traditional doctoral when he says, 'There are more checks and balances in awarding Ph.D.s on published work than in the more enclosed system ... that is not generally in the public arena.'

The distinguished British ecologist, Kenneth Mellanby,⁷ has gone as far as to recommend that the Ph.D. thesis in its present form should be abolished and that doctoral candidates should simply submit their published work for consideration. He comments that, 'my own Ph.D. thesis consisted simply of a reprint of a 14-page paper published in the *Proceedings of the Royal Society*.'

It will not be easy to break the increasingly archaic stranglehold of the traditionalists. However, as a constructive first step, universities in this country should

consider stipulating that, despite the completion of a thesis, no Ph.D. will be awarded until the work has resulted in the acceptance of at least one publication in an appropriate journal. A survey of the master's and Ph.D. degrees awarded at the University of Zululand shows that less than 10% have given rise to any such publication. Is the situation any better elsewhere?

Halstead⁸ advises that, 'A Ph.D. should not be awarded until there is evidence that major new contributions to science have been published ... in an appropriate reputable journal. If the material is not suitable for publication then it was not necessary for it to be done in the first place.'

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In Brief

New status for MRI

The University of Pretoria's Mammal Research Institute has been granted fully autonomous status, with Professor John Skinner as the first full-time director. The MRI had previously been incorporated in the Department of Zoology, of which Skinner was head. The Department merged with that of Entomology last year. The aim of the Institute will remain the training of students for higher degrees, research on mammals and international liaison and collaboration. (For a review of its multifarious research interests reported at its 21st anniversary conference, see *S. Afr. J. Sci.* 83, 586–663.)

The MRI was launched in 1966 with the late Professor Waldo Meester as the first director. The University has decided that henceforth the director will hold the Austin Roberts Chair of Mammalogy, to acknowledge the first recipient of an honorary D.Sc. degree, awarded posthumously in 1935, for the research that led to the

encyclopaedic *The Mammals of South Africa*.

Funding for the science councils

The Department of Arts, Culture, Science and Technology will distribute the following subsidies for the science councils for the 1995–6 financial year: Agricultural Research Council R220.3 million, Mintek R59.7m (including R2.06m for agency funding), Medical Research Council R47.6m (R3.18m), Human Sciences Research Council R80.5m (R16.6m), Council for Geoscience R43.9m, SA Bureau of Standards R40.9m, Foundation for Research Development R130.8m (including R33.5m for the National Accelerator Centre, R3.7m for the Hartebeesthoek Radioastronomy Observatory and R7.0m for the South African Astronomical Observatory), and for the CSIR R231.1m.

The total budget for science will work out at nearly R856 million, which includes R2 million for the running of the Department and R6 million for the renewal of equipment at the historically black universities and technikons. □

pH Calculations for Chemists and Biologists

SAJ Sci, 85(6), 1989, pp 386-388

Not available online, but here is a Google AI Overview:

Based on search results, the article "**pH Calculations for Chemists and Biologists**" by **I.J. McNaught** and **G.D. Peckham** was published in the *South African Journal of Science* in 1989.

- **Publication Reference:** *South African Journal of Science* 85(6): 386 in 1989.
- **Authors:** I.J. McNaught and G.D. Peckham.
- **Topic:** The article covers practical methods for calculating the pH of solutions, which is relevant to both chemical and biological studies.

This article derives an equation for calculating exact pH values for mixtures of weak acids and bases in aqueous solution, without solely relying on the approximations involved by the use of the Henderson–Hasselbalch equation

PH CALCULATIONS FOR CHEMISTS AND BIOLOGISTS

Authors IJ McNaught, GD Peckham

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P-V Diagrams Have More to Offer

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Textbooks that cover thermodynamics at an introductory level routinely follow an introduction to the First Law with a number of applications involving ideal gas processes. These processes are usually illustrated by the use of appropriate P - V diagrams.

However, use of these diagrams is commonly restricted to a few of the following four simple cases: reversible or constant pressure expansions under isothermal conditions and reversible or constant pressure expansions under adiabatic conditions. Several other applications of P - V diagrams are suggested here.

Various Thermodynamic Processes

The individual, verbal definitions of isobaric ($dP = 0$), isothermal ($dT = 0$), adiabatic ($Q = 0$), and isochoric ($dV = 0$) processes are easily understood by students. Figure 1 is a useful way to present a visual distinction between these four processes. It also emphasizes that an ideal gas subjected to these processes may, and in most instances will, end up at a different temperature in each case. This is an important fact that is not apparent from the verbal definitions.

There is a pedagogic value of superimposing all four processes on a single P - V diagram because it not only identifies the process, but simultaneously shows how it differs from the other processes.

Why C_p May Be Used for Constant Volume Processes

Students readily accept that $\Delta U = C_V \Delta T$ when an ideal gas is heated at constant volume, but find it difficult to understand why the C_p is not substituted

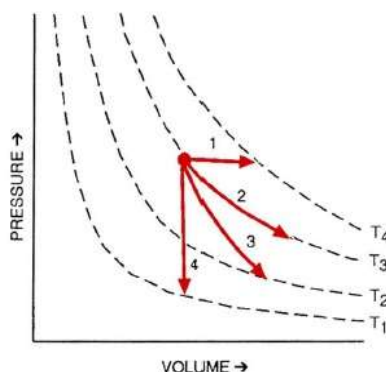


Fig. 1. Various thermodynamic processes. 1. Isobaric (Constant pressure; Charles Law); 2. Isothermal (Constant temperature; Boyle's Law); 3. Adiabatic (No heat exchange with the surroundings); 4. Isochoric (Constant volume; Amonton's Law).

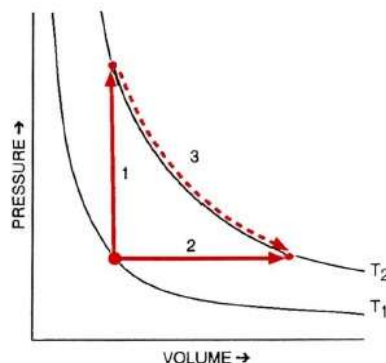


Fig. 2. $\Delta U = C_V \Delta T$ for both isochoric (1) and for isobaric (2) processes.

for C_V when the process occurs at constant pressure. Figure 2 provides a simple visual explanation: If the gas undergoes an isochoric (constant volume) process, it will follow arrow 1, for which $\Delta U = C_V \Delta T$. On the other hand, if the gas undergoes an isobaric (constant pressure) process, it will follow

arrow 2. To show that ΔU is still equal to $C_V \Delta T$ for this process, it is only necessary to remember that ΔU is a state function and note that:

$$\begin{aligned}\Delta U_2 &= \Delta U_1 + \Delta U_3 \\ &= \Delta U_V + \Delta U_T \\ &= C_V \Delta T + 0 \\ &= C_V \Delta T\end{aligned}$$

Thus $\Delta U = C_V \Delta T$ for both constant volume and constant pressure processes. Similarly, $\Delta H = C_p \Delta T$ for both constant pressure and constant volume processes.

Processes in Which P , V , and T All Change

The P - V diagrams used in textbooks are invariably confined to processes in which a particular variable is held constant—as in Figs. 1 and 2. This is a sound way to introduce the basic concepts to students, but it is a particularly useful exercise to link these various processes by considering cases in which none of the basic variables is held constant (see Fig. 3). Such an example also provides the opportunity to emphasize the fact that changes in state functions depend only on the initial and final states of the system and are independent of the pathway between these states.

In Fig. 3, arrow 1 is the process of interest, in which P , V , and T all undergo a change of state from $P_1 V_1 T_1$ to $P_2 V_2 T_2$. For such a case we have

$$\begin{aligned}\Delta U_1 &= \Delta U_2 + \Delta U_3 \\ &= \Delta U_V + \Delta U_T \\ &= C_V \Delta T + 0 \\ &= C_V \Delta T\end{aligned}$$

or

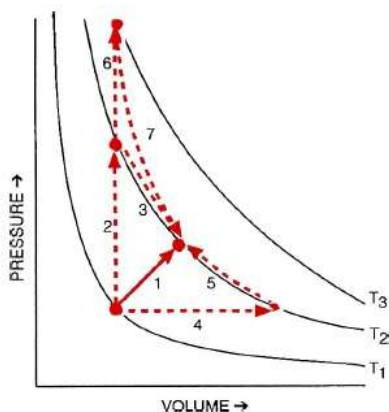


Fig. 3. A process in which P , V , and T all change.

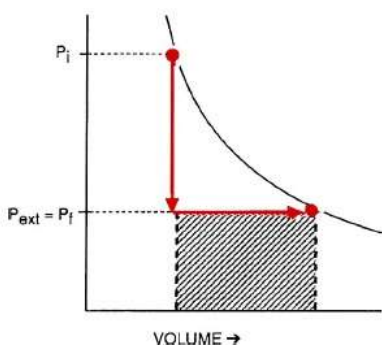


Fig. 4a. Isothermal expansion against an external pressure that is equal to the final pressure of the system.

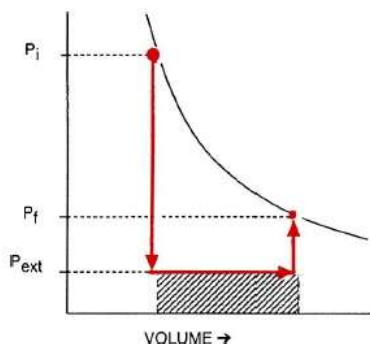


Fig. 4b. Isothermal expansion against an external pressure that is less than the final pressure of the system.

$$\begin{aligned}\Delta U_1 &= \Delta U_4 + \Delta U_5 \\ &= \Delta U_P + \Delta U_T \\ &= C_V \Delta T + 0 \\ &= C_V \Delta T\end{aligned}$$

$$\text{Similarly, } \Delta H_1 = \Delta H_2 + \Delta H_3 = \Delta H_4 + \Delta H_5 = C_P \Delta T.$$

In Fig. 3, the second step (3 or 5) is isothermal. This provides the easiest and most convenient solution. However, the independence of pathway may be further illustrated by electing to make the second step adiabatic. Despite the change of pathway, the same end result is still obtained:

$$\begin{aligned}\Delta U_1 &= (\Delta U_2 + \Delta U_6) + \Delta U_7 \\ &= \Delta U_V + \Delta U(\text{rev, adiabatic}) \\ &= C_V(T_3 - T_1) + C_V(T_2 - T_3) \\ &= C_V(T_2 - T_1) \\ &= C_V \Delta T\end{aligned}$$

Pressure against Which a Gas Expands Not Necessarily Final Pressure of the Gas

Textbooks and teachers generally take care to explain that the work done by an expanding system depends, not on the pressure of the system, but on the *external* pressure against which the system expands. Having done that, most of the supporting examples, and virtually all of the relevant P - V diagrams are of such a nature that the system expands against a pressure that is exactly equal to the final pressure of the system (see Fig. 4a). This is not wrong, but allows students to obtain correct results by incorrectly using P (final) instead of P (external). This is best avoided by making use of examples, illustrated by a P - V diagram such as Fig. 4b, in which P (external) $< P$ (final).

What about Compressions?

The vast majority of P - V diagrams illustrate expansion processes only. It is well worth mentioning to students that compression processes are equally important. The use of P - V diagrams such as Fig. 5 (in conjunction with Fig. 4) is one of the many ways in which P - V diagrams may be employed to illustrate this point. By comparing Figs. 4 and 5, it is also apparent that the work done (shaded area) by an expanding system is always less than (or, for reversible processes, equal to) the work required to

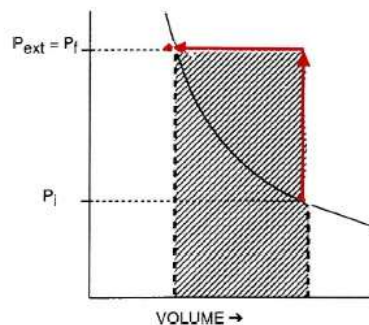


Fig. 5a. Isothermal compression by an external pressure that is equal to the final pressure of the system.

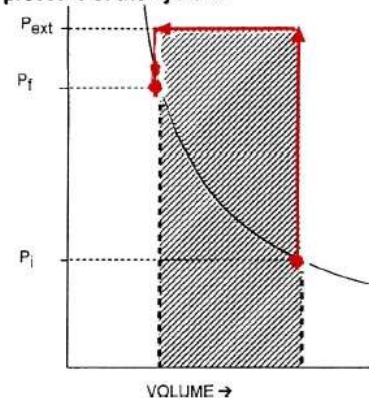


Fig. 5b. Isothermal compression by an external pressure that is greater than the final pressure of the system.

restore the system to its original state—goodbye to perpetual motion and such.

Conclusion

It is a basic pedagogic principle (i.e., common sense!) that improved comprehension results from the reinforcement of an idea by approaching it from several different angles. Thus many scientific concepts may be defined verbally, reinforced by an equation, further reinforced by an appropriate diagram and finally, illustrated by a suitable calculation. Diagrams are especially appreciated by students, for whom the old adage, “A picture is worth a thousand words” seems to apply. As a result, P - V diagrams are a particularly useful, but under-exploited, teaching aid; this note provides some suggestions for extending their usefulness.

Thermodynamic studies on metal-ligand complexes: copper(II) complexes of alanine, phenylalanine and catechol

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The enthalpies of deprotonation of the ligands alanine, phenylalanine and catechol are reported, along with the enthalpies of formation of their corresponding copper(II) complexes. The feasibility of using the enthalpies of formation to elucidate the differences in the nature of the bonding in copper(II)-dopa and -methyldopa complexes is discussed.

Verslag word gegee van die deprotoneringsentalpies van die ligande alanien, fenielalanien en katesjol, tesame met die vormingsentalpies van die ooreenstemmende koper(II) komplekse. Die uitvoerbaarheid om die vormingsentalpies te gebruik om die verskille in aard van die binding in koper(II)-dopa en -metioldopa komplekse te verduidelik, word bespreek.

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The catecholamines and their derivatives play a major role in various neurological processes.¹ An important example is the application of 3-(3,4-dihydroxyphenyl)-L-alanine (dopa) to the treatment of Parkinson's disease. This was first reported by Birkmayer and Hornykiewicz² in 1962. Calne and Sandler³ subsequently established that gross depletion of striatal dopamine occurs in Parkinsonian patients and Cotzias et al.⁴ showed that prolonged oral administration of large doses of dopa brings about sustained improvement in such patients.

The current opinion is that the therapeutic activity of dopa in Parkinsonism derives from its intracerebral conversion to dopamine. Dopa gains ready access to the central nervous system,⁵ unlike other catecholamines which have difficulty crossing the blood-brain barrier.³ However, rapid extracerebral decarboxylation of dopa reduces the amount of dopa reaching the brain. Sourkes⁶ and Sandler et al.⁷ have suggested that the therapeutic effects of dopa probably involve a number of minor metabolic pathways in addition to the simple dopa-dopamine conversion. This suggestion is supported, for example, by reports that enzymes containing copper(II) ions catalyse transformations of catecholamines^{8,9} and that transport of dopa across the blood-brain barrier is facilitated by chelation to copper(II) ions.¹⁰ This chelation is also reported to reduce extracerebral decarboxylation of dopa.¹¹

A closely related drug, 3-(3,4-dihydroxyphenyl)-2-methyl-L-alanine (methyldopa), has become an important therapeutic agent for treating hypertension,¹² though the mechanism of its clinical action is also not fully understood.¹³ However, the close relationship

between dopa and methyldopa gives reason to suspect that chelation to copper(II) ions may also be significant in the case of methyldopa. A deeper understanding of the chemical behaviour of dopa and methyldopa may lead to a clearer insight into their clinical mechanisms. This may in turn lead to the development of improved forms of these drugs which could contribute to the therapy of prevalent Parkinsonism and hypertension.

Methyldopa may be expected to form a set of copper(II) complexes with the same stoichiometry as those of the copper(II)-dopa complexes, but with slightly different values for the corresponding formation constants. Unfortunately, differences of opinion are expressed in the literature regarding the identities of these complexes.

At low pH, Gorton and Jameson^{11,14} envisaged mononuclear complexes involving chelation exclusively at the alanine end of the dopa molecule (*O,N* coordination), as shown in Figure 1(a). In alkaline solutions they obtained evidence of chelation exclusively at the catechol end of the molecule (*O,O* coordination), as shown in Figure 1(b). They further postulated the existence of polymers at high metal-to-ligand ratios. Both *O,N* and *O,O* coordination must necessarily occur in such polymers. A copper(II)-dopa complex with mixed *O,N* and *O,O* coordination is shown in Figure 1(c).

By contrast, Gergely and Kiss¹⁵ and Kwik et al.¹⁶ found mononuclear complexes with both types of chelation occurring, particularly in the pH range, of physiological importance.

If we represent the dopa (or methyldopa) dianion as L, the copper(II) ion as M and a proton as H, then mononuclear complexes of the form ML_2H_2 may be

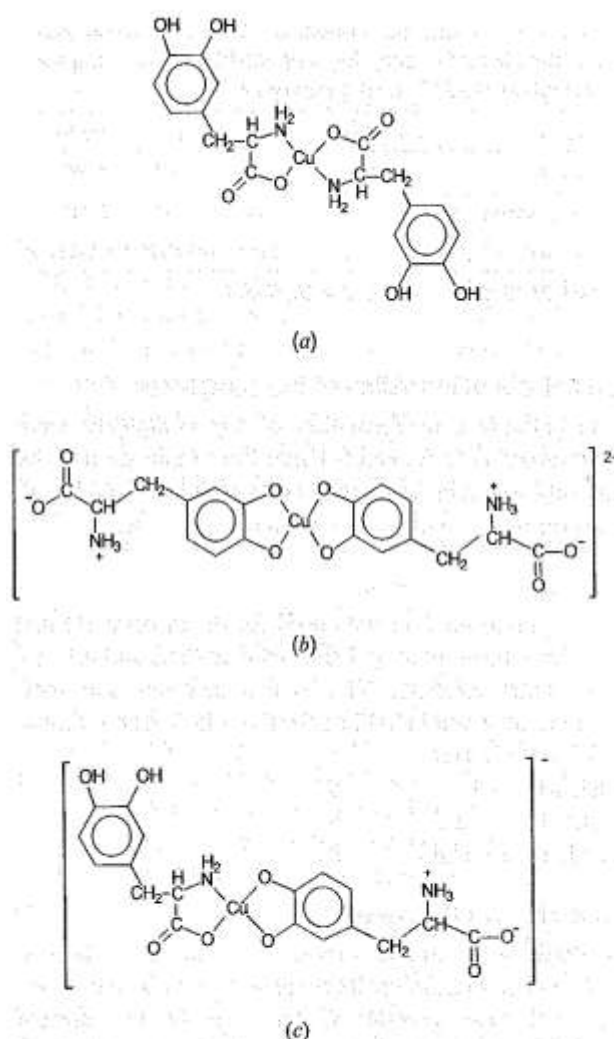


Figure 1 Some copper(II)-dopa complexes: (a) *O,N/O,N* coordination; (b) *O,O/O,O* coordination; and (c) *O,N/O,O* coordination.

expected to exist. The investigations of Gergely and Kiss,¹⁵ Kwik et al.¹⁶ and Linder and co-workers¹⁷ have found mononuclear complexes with *x:y* being 1:1, 1:2, 2:2, 2:1, 2:0, 2:-1 and 2:-2. The concentrations of the various possible complexes and the nature of their coordination vary with pH and the controversy outlined above centres largely on the ML_2H_0 complex, for which Gergely and Kiss¹⁵ and Kwik et al.¹⁶ proposed *O,O* binding for both ligands, while Linder and co-workers¹⁷ produced evidence of mixed *O,N* and *O,O* coordination.

If titration calorimetry is to be used to establish the mode of coordination in the ML_2H_0 complex, then it is clear that values for the enthalpy of coordination for both *O,N*- and *O,O*-type coordination with copper(II) ions must first be determined separately and must be found to be distinguishable. Having achieved this, calorimetric data for the formation of the ML_2H_0 complex should lead to conclusions regarding the mode of coordination of the ligands in that complex.

With the copper(II)-methyldopa system, however, it

is impossible to find a pH at which all the various complexes present occur with exclusively *O,N* coordination or with exclusively *O,O* coordination. Apart from other complications, the presence of minor complexes at any given pH precludes the use of the copper(II)-methyldopa system itself to determine the required enthalpies of coordination with any accuracy. This paper reports the determination of the enthalpies of coordination for *O,N*- and *O,O*-type coordination with copper(II) ions using model ligands. Alanine and phenylalanine were chosen to represent the alanine end of the methyldopa molecule. Catechol itself was chosen to represent the catecholate end of the methyldopa molecule. Each of these bidentate ligands is capable of forming only complexes of the type ML and ML_2 with copper(II) ions. This greatly reduces the complexity of the system and facilitates the determination of the enthalpies of reaction. A comprehensive discussion of the coordination chemistry of copper has been provided by Hathaway;¹⁸ the various copper-ligand complexes for alanine and catechol are illustrated in Figure 2.

Experimental

Materials

The certificated reagents alanine, phenylalanine and sodium perchlorate (all Merck A.R. grade, metals <0.002%) were used, after drying, without further purification. Catechol (BDH) was purified by sublimation under reduced pressure and stored in a dark glass vessel to reduce photolytic decomposition. A stock solution of copper(II) ions was prepared by dissolving a precise mass of copper(II) oxide (Merck, A.R. grade) in perchloric acid (70%; Riedel-de Haën, A.R. grade) according to the method of Athavale et al.¹⁹ The

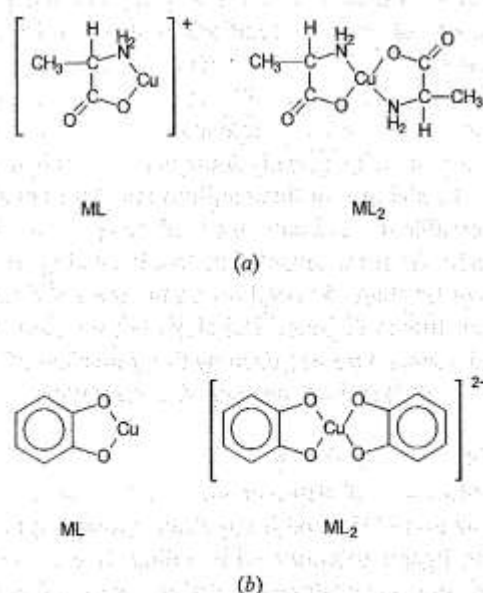


Figure 2 The ML and ML_2 complexes of alanine and catechol: (a) copper(II)-alanine; and (b) copper(II)-catechol.

concentration of copper was then checked using a standard iodometric procedure.²⁰

Hydrochloric acid and sodium hydroxide solutions were made up from Merck Titrisol® reagents. The sodium hydroxide solutions were protected from atmospheric carbon dioxide by degassing and then storing under nitrogen. A soda-lime guard tube protected the sodium hydroxide supply in the reservoir. The titrant concentration is a critical factor in subsequent calculations; hence the sodium hydroxide solutions were standardized, after dilution, with potassium hydrogen phthalate (99.9%; Riedel-de Haën) using a gravimetrically calibrated burette and pipette.

All solutions were made up with freshly prepared conductivity water. The ionic strength of titrand solutions was adjusted to 0.1 mol dm⁻³ by addition of sodium perchlorate.

Apparatus

Enthalpy changes were determined using a custom-built microcalorimeter. This was designed around the LKB 8700 titration calorimeter system.²¹ The cell assembly is undoubtedly of high quality; however the electronic control circuitry of this commercial system left a great deal of room for improvement in sensitivity and precision. The electronic circuitry used in this investigation was built by Stiff.²² A resolution of about 10⁻⁵ K was obtained by using a high-precision resistance box to balance the bridge and feeding the out-of-balance signal via an amplifier to a chart recorder.

Procedure

Prior to an experiment, the electronic systems, isothermal baths and the laboratory room thermostating system were run overnight to establish a steady operating state. Attainment of thermal equilibrium was confirmed by balancing the bridge. The characteristic equilibrium thermistor resistance of 1927 Ω was found if the cell was at the required temperature (25.00°C) and a recorder trace with a steady Joule heating gradient testified to the stability of this equilibrium. With practice it was possible to estimate the cell temperature fairly accurately from the slope of the Joule heating trace on the recorder chart. At equilibrium the trace had a slope of about fifteen degrees. The slope became zero when the cell temperature had risen by the equivalent of about 1.2 Ω (0.01°C) and became negative thereafter.

Enthalpies of ligand deprotonation

The enthalpies of deprotonation of the ligands were determined at 25°C and 0.1 mol dm⁻³ ionic strength by titrating ligand solutions with sodium hydroxide. The alanine and phenylalanine solutions were acidified to protonate the carboxyl group, thereby ensuring that both enthalpies of deprotonation could be determined.

Table 1 Equilibrium constants for the deprotonation of the ligands and for copper(II)-ligand complex formation at 25°C, *I* = 0.1 mol dm⁻³

Ligand	pK ₁	pK ₂	log K ₃	log K ₄
Alanine	2.35 ^a	9.69 ^b	8.13 ^b	6.79 ^b
Phenylalanine	2.258 ^c	9.194 ^c	7.931 ^c	6.903 ^c
Catechol	9.195 ^d	12.98 ^d	13.827 ^e	10.921 ^e

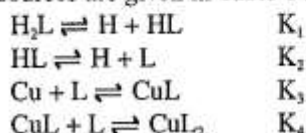
^aRef. 23; ^bRef. 24; ^cRef. 25; ^dRef. 26; ^eRef. 27.

Enthalpies of formation of the complexes

The enthalpies of formation of the complexes were determined at 25°C and 0.1 mol dm⁻³ ionic strength by titrating solutions containing copper(II) ions and ligand, in various mole ratios, with sodium hydroxide.

Equilibrium constants

The equilibrium constants used for the systems studied here have been reliably determined at 25°C and 0.1 mol dm⁻³ ionic strength. The values selected and their sources are given in Table 1 for the following equilibria:



Results and Discussion

It should be noted that although ΔH values for the systems under discussion here are available in the literature,²⁸ it was crucial, if the aim of the present investigation was to be accomplished, for a series of appropriate calorimetric measurements to be made under identical conditions, using the same apparatus and experimental methodology.

The results for the enthalpies of deprotonation of the ligands are presented in Table 2.

The second enthalpy of deprotonation for catechol could not be determined. The catecholate anion is readily oxidised²⁹ to quinone species,³⁰ especially in solutions with a pH exceeding about 8.²⁶ The enthalpy of oxidation is relatively large and interferes with the determination of ΔH₂ by titration calorimetry.²⁶ A protracted attempt to determine ΔH₂ by microflow calorimetry proved unsuccessful. In order to eliminate all possibility of oxidation, ΔH₁ was determined using only small (approximately 0.01 cm³) additions of titrant. Less than 15% of the catechol was neutralised and thus

Table 2 Enthalpies of deprotonation (kJ mol⁻¹) of the ligands

Ligand	ΔH ₁	σ(ΔH ₁)	ΔH ₂	σ(ΔH ₂)
Alanine	3.0	0.5	46.4	0.2
Phenylalanine	2.3	0.2	44.9	0.2
Catechol	30.7	0.4	—	—

Table 3 Enthalpies of formation (kJ mol⁻¹) of the copper(II)-ligand complexes

Complex (Coordination mode)	ΔH_{ML}	$\sigma(\Delta H_{ML})$	ΔH_{ML_2}	$\sigma(\Delta H_{ML_2})$	ΔH_{Total}	$\sigma(\Delta H_{Total})$
Cu(II)-alanine (O,N/O,N)	-22.6	0.7	-25.4	0.3	-48.0	0.8
Cu(II)-phenylalanine (O,N/O,N)	-20.8	1.3	-25.6	0.2	-46.4	1.3
Cu(II)-catechol (O,O/O,O)	-19.4	0.3	-24.3	0.2	-43.7	0.4

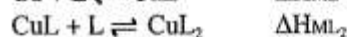
the pH remained too low for oxidation to occur.

The only value of ΔH_2 for catechol in the literature is that of Jameson and Wilson,²⁶ who give ΔH_2 as 21 kJ mol⁻¹ at 25°C and 0.1 mol dm⁻³ ionic strength (KNO₃). This value was determined potentiometrically and is stated to be approximate. In the absence of any better estimate, 21 kJ mol⁻¹ was accepted as the value of ΔH_2 for catechol and used in the calculation of the enthalpy change for the copper(II)-catechol complex.

The results for the enthalpies of formation of the copper-ligand complexes are given in Table 3 and are based on the assumption that only the ML and ML₂ species are formed. This is in agreement with the conclusions of Izatt et al.³¹ However, Curchod³² has presented evidence that under certain experimental conditions various minor complexes may occur. Linder³³ supports the existence of minor complex species but differs from Curchod as to their identities. In any event, these minor species begin to appear only when the pH exceeds about 6.

The aim of this investigation centred on the determination of the enthalpies of complex formation for O,N and O,O modes of coordination of model ligands with copper(II) ions. This having been achieved, the elucidation of the nature of the bonding in the copper(II) complexes formed with the clinically important ligands, dopa and methyl-dopa, then becomes a possibility. This possibility is now examined.

The equilibria in question and their enthalpy changes are:



whence



The results for exclusively O,N coordination using the alanate ligands and for exclusively O,O coordination using the catecholate ligand can be seen in Table 3. If cognisance of the precision of the determination of the enthalpies of formation is taken into account, it is reasonable to assume that it will be possible to distinguish calorimetrically between enthalpies of reaction which differ by about 4%. Thus, using titration calorimetry,

it should be possible to distinguish between the total enthalpies of formation, ΔH_{Total} , of complexes formed with exclusively O,N or with exclusively O,O coordination.

Complexes formed with dopa-type ligands and showing mixed complexes present a more difficult problem. There seems little doubt¹⁷ that the intermediate complex ML of the mixed complex MLL' shows O,N coordination. On this basis the total enthalpy of formation of the mixed complex may be predicted; these predictions are given in Table 4.

Unfortunately, the predicted values of ΔH_{Total} for mixed coordination are not sufficiently different from those of ΔH_{Total} for exclusively O,N or exclusively O,O coordination to allow a clear distinction to be made by calorimetric studies alone. We have to conclude, therefore, that it is not feasible to use the enthalpies of formation to elucidate the differences in the nature of the bonding in copper(II)-dopa and -methyl-dopa complexes.

Acknowledgement

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Table 4 Predicted enthalpies of formation (kJ mol⁻¹) for mixed O,N/O,O-type complexes with copper(II)

ΔH_{ML}	ΔH_{ML_2}	ΔH_{Total}
-22.6 (alanine)	-24.3 (catechol)	-46.9
-20.8 (phenylalanine)	-24.3 (catechol)	-45.1

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A re-appraisal of assessment practices in the light of the South African Qualifications Authority (SAQA) Act

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ABSTRACT

There is no denying the influential role that assessment plays within the curriculum. However, increasing student numbers and limited resources make the task of meaningful assessment a difficult one. Higher Education institutions are being forced to resort to assessment for accreditation at the expense of assessment for learning. However, the implementation of the South African Qualifications Authority (SAQA) Act of 1995, makes a shift in assessment paradigm necessary. In addition, teaching staff need to cope with increasing numbers of inadequately prepared students. Computer-assisted assessment is one avenue staff may pursue. However, involving the learner in the assessment process by means of collaborative and authentic assessment practices, might afford the ultimate medium for the inculcation of life-long learning.

PREAMBLE: THE ROLE OF ASSESSMENT IN THE LEARNING PROCESS

"Learning is so driven by assessment, that the form and nature of assessment often swamp the effects of any other aspect of the curriculum" (Boud 1990: 103).

There is no denying the influential role that assessment plays within the curriculum. In Higher Education, much of the curriculum is assessment driven: in other words, assessment tasks define the curriculum in the sense that students often focus on topics that are to be assessed in the hope of getting good marks. In this way, assessment impacts on the learning process.

If assessment is used as a tool for learning, it can impact positively on student performance. In order to maximise these positive effects, educators in the Higher Education sector need to use assessment as a means of promoting good teaching and learning. The successful implementation of the South African Qualifications Authority (SAQA) Act of October 1995, means that assessment can no longer assume a purely summative role in the learning process, as it has often done in the past. In future, educators will need to show evidence of having made use of a finely balanced blend of summative and formative assessments. The SAQA Bulletin of 1997 suggests that assessment is increasingly to be seen as a tool for learning. This document, together with the SAQA ACT of 1995 is available on the World Wide Web site at www.saqa.org.)

THE CHANGING PROFILE OF HIGHER EDUCATION

Institutions of Higher Education are increasingly being characterised by the following:

- Large classes – it is unlikely in the present economic and political circumstances that staff-student ratios will improve.
- Disadvantaged learning backgrounds – many students who are now entering tertiary education have developed receptive as opposed to productive learning skills. In difficult and cognitively demanding situations students develop coping strategies such as the reliance on rote learning, which leads to what Entwistle (1987) refers to as surface learning rather than deep learning.
- Limited administrative assistance – decreased resources will also impact on the amount of administrative assistance made available to staff.

These and other features will make it necessary for

Table 1
Purposes of Assessment

	Diagnostic	Formative	Summative
Aim	prediction	aims at improving the quality of learning – developmental	accreditation of knowledge (Boud 1990) – gate-keeping
Motivation	administrative reasons (Boud 1990)	intrinsically motivated; serves the needs of the student (Boud 1990)	extrinsically motivated; serves the needs of the external world (Boud 1990)
End result	remediation	tests effectiveness of learning outcomes	educational decision making
Example	alternative admission strategies, foundation courses	learning journals	formal tests and examinations

staff at institutions of Higher Education to find innovative ways of enhancing teaching and learning through assessment under the present constraints of having limited resources.

THE PURPOSES OF ASSESSMENT

Table 1 above summarises three broad uses of assessment in Higher Education.

A SHIFT IN PARADIGM

Assessment practices are influential in determining whether students adopt a deep or surface approach to learning. In addition to the SAQA Bulletins of 1997 and 1998, the National Guidelines for Assessment, produced by the National Department of Education, show the need for a major paradigm shift in assessment, and this reflects a changing perception worldwide of the nature of assessment and of its main purposes (see the executive summary of these Guidelines). Not only is a shift in paradigm essential, but it is also desirable in terms of the benefits that learners will derive from it.

Research which focuses on teaching and learning with limited resources already suggests that teaching staff should move away from the traditional methodologies to alternative ones, in order to cope with increasing numbers of inadequately prepared students. Traditionally, assessment has been almost entirely summative in nature, with the requirement that the educator be sole and unconditional judge or arbitrator of quality. There is evidence of some use of formative assessment even in a traditional framework of assessment, but this has usually occurred in small

and isolated pockets of quality. SAQA now expects educators to show that they used a range of summative and formative assessments (SAQA Bulletin 1997: 15).

If the quality of assessment is to be enhanced within the present constraints, then educators will need to reconsider these notions. As unpalatable as this may seem, they will need to acknowledge that fellow learners, and indeed learners themselves, can make a meaningful contribution to the assessment process. Involving the learner in the process of assessment has benefits beyond the practical ones: if we are to inculcate a culture of life-long learning, learners need to be trained to assess their own worth.

The distinctions between traditional assessment and the kinds of practices expected by SAQA are not indisputable and absolute, nor do they reflect a continuum. Table 2 below highlights these differences in very broad terms.

Boud (1990: 102) claims that there is often a gap between what we encourage students to focus upon for the purposes of assessment, and what is needed for meaningful learning to take place. There exists a need to correlate our aims of teaching with our aims of assessment: if we teach to encourage deep learning (Entwistle 1987) we need to use assessment techniques that foster such learning. If we continue to reward the reproduction of knowledge, and rely heavily of an examination system only, we run the risk of encouraging only surface learning. (This is not to say that examinations, per se, cannot assess deep learning: a well-constructed examination can assess whether or not students have a deep or a surface understanding of the subject.) Because of this staff need to examine their assessment practices to see if

Table 2
The traditional and alternative paradigms

Traditional paradigm	Alternative paradigm as suggested by SAQA
summative focus (for grading)	formative focus (for learning)
judgemental in nature	developmental in nature
focuses on content	focuses on the learning process
teacher-led assessment	student-led assessment
separate from course design	perspective of the curriculum
isolated from learning process	integral part of the learning process
reliance on examinations	variety of methods
implicit criteria	explicit criteria
norm-referenced criteria	self-referenced or criterion-referenced criteria
over-emphasis on memory and lower order thinking skills	emphasis on critical thinking and higher order thinking skills
encourages surface learning	encourages deep learning
decontextualised assessments	authentic assessment practices

they are compatible with their goals for higher education and with the critical outcomes specified by the SAQA.

There is also a pressing need to change students' perceptions about assessment: at present many students see assessment as a punitive and discriminatory exercise. Few students see assessment as an opportunity to enhance their own skills and knowledge. Students are often highly resistant to new methodologies, and in particular to continuous assessment practices. They need to be encouraged to see the correlation between marks derived from continuous assessment and their academic performance: it is unlikely that a student who has failed to demonstrate successful learning during the course of the year will demonstrate sufficient evidence of deep learning in examinations. All this is compounded by the resistance that students from backgrounds of "disadvantage" display to new and innovative teaching and learning.

In the new paradigm of meaning-based pedagogies, the learner is viewed as being an active seeker and constructor of knowledge, rather than a passive receiver (Engel 1994: 22). If we see learning as an active endeavour, as this paradigm does, then we must assert, as Boud (1990: 109) does, that it is only the learner who can learn and implement decisions about his or her own learning. This has implications

for self-assessment (to be discussed in more detail later).

CONTINUOUS ASSESSMENT (CASS) WITH POSITIVE EFFECT

In order for the new paradigm of assessment, as espoused by the SAQA, to be successful, educators will also need to inculcate a culture of assessment where not all that is assessed is for grading purposes. In keeping with Curriculum 2005, continuous assessment has been suggested by SAQA. Educators may feel that it is not possible due to a lack of resources. However, educators are not being asked to do more, they are being asked to do better.

The following advantages of continuous assessment can be beneficial to teaching where staff are faced with assessing large groups of students:

- Adjustments can be made to the course while in progress (see Grayson 1995).
- Problems in learning can be diagnosed at an earlier stage in the students' progress.
- Staff receive more immediate feedback to their courses and to their students' learning.
- Assessment carried out on a continuous basis is a more reliable indicator of successful learning, in that it uses a wider range of techniques, on a regular basis, making the evidence of successful

learning more consistent over a range of skills than sporadic, once-a-semester testing.

- Assessment becomes part of the students' learning processes.

Here it becomes necessary to draw a distinction between continuous assessment and continual (also sometimes referred to as 'intermittent') assessment. Many educators undertake continual assessment in the name of continuous assessment. The latter is a way of assessing student learning in a formative and developmental manner, where the lecturer is not always the sole judge of quality. The former on the other hand, still functions in a traditional manner, with the lecturer as the sole judge of quality, but has the emphasis on repeated evaluations of student learning in the same manner, with variation of technique for the purpose of educational decision making.

Continual assessment might use the same technique of examining students repeatedly at short intervals, whereas continuous assessment uses a variety of approaches and uses the feedback from each assessment to inform the construction of the next. Continuous assessment suggests a cyclic process, rather than a repeated (and often terminal) process (continual assessment).

Boud (1990:103) points out a reality when he explains that resource pressures increasingly lead us to resort to assessment for accreditation at the expense of assessment for learning. With the present constraints, it would seem unreasonable to expect staff to take on heavier marking loads. However, continuous assessment practices need not necessarily demand this. Innovative assessment techniques need to be found to deal with the situation.

COMPUTER-AIDED ASSESSMENT

Technology is available to assist staff in assessing students. Grayson (1995) points out that using a pretest before a new topic is tackled in the lecture has a variety of advantages including whetting the students' appetites for the topic, and alerting the lecturer to any misconceptions that the students may have. It is possible to make use of computer-aided testing to do this. Access to software (like for example, Question Mark) that has been designed for this purpose, has made it possible to use the computer as an additional assessment tool. The development of optical mark readers which scan students' multiple choice tests is yet another way in which technology can assist and complement the role that the lecturer plays in assessing students. This technology can be useful in performing short pre-tests for learners in

order to reveal to both learner and educator the extent of their existing understanding of a topic.

The successful development of multiple choice questions (required by both Question Mark and the optical mark reading technology) is not within the scope of this paper. However, the quality of this kind of assessment can no longer be ignored. While this type of assessment has attracted a great deal of criticism from a variety of circles, this criticism should be directed more at the quality of multiple choice tests than to the potential of the method. Because of poorly conceived questioning techniques, multiple choice questions have been used almost exclusively for the testing of factual recall. It has also been exploited by educators who have used it as the only method of assessment. The SAQA recommendations can be accommodated by this kind of testing, if it is one of a variety of testing methods to be employed. (The SAQA Bulletin of 1997 (p 15) makes mention of using a range of formative and summative assessment methods.)

Research conducted at the University of Cape Town (see Paxton 1997) suggests that the use of multiple choice questioning is actually on the increase. This is not necessarily alarming as there is an increasing body of research that suggests that multiple choice questioning *can* test students' higher orders of thinking successfully (see for example le Roux 1996, Killoran 1992, Karras 1991 and Van Ede 1994). The increasing range of variants within the broad category of multiple choice testing, make the use of multiple choice questioning a viable option for large classes. In addition, the statistical analysis of student results, which can easily be facilitated by multiple choice questioning, provides useful and immediate feedback to educators with regard to possible student misconceptions about the study material.

COLLABORATIVE ASSESSMENT

Peer assessment in general is widely reported as being a rare assessment technique (Candy 1994). However, it remains a very powerful tactic. While it can assist staff in spreading the marking load, more importantly, it provides students with insights as to the range of standards that the assessor encounters, and in a sense, places the student's own writing in perspective. As a means of formative assessment, it can take the form of students' reviewing each other's writing prior to work being submitted.

While used for the purposes of formative assessment, peer review remains uncontroversial. However, this kind of assessment takes on a new and more

controversial nature if used for summative assessment purposes. However, research shows that if students have sufficient guidance, the assessment they make can be highly reliable. (The use of student-derived marks for formal and reliable grading purposes is discussed at length in Kwan and Leung 1996.) A sustained process of peer review (peer mentoring) is one methodology that can be used to reduce the amount of feedback that the educator needs to provide to learners on a regular basis.

The present ethos of education in South Africa encourages learners to become life-long learners and one of the essential criteria for developing life-long learning is self-directed learning. Such learners are autonomous and take responsibility for their own learning. Candy (1994: 150) makes a relevant point in this regard: "If students are to be encouraged to be life-long learners, they must be weaned away from any tendency towards over-reliance on the opinions of others. Ultimately, in real world learning context, they must be able to judge or evaluate the adequacy, completeness or appropriateness of their own learning, so whatever assessment practices are used must be comprehensible to the learners as that they can be internalised as criteria for critical self-evaluation".

Boud (1990: 110) cites research that shows that students are able to make judgements about their own learning, and that by encouraging them to do so assists them to take responsibility for their own learning and helps develop those skills which they need to continue to pursue their learning outside the institution. "Assumptions that learners are unable to make judgements undermine their capacity to do so" (ibid: 109).

He cautions, however, that such self-assessment cannot take place entirely independently of others: assessments by peers and staff are essential in assisting learners to form sound judgements (ibid: 109). He concludes the argument by saying that: "Self-assessment in isolation is probably not a fruitful path to follow, but when moderated and used as an element of collaborative assessment its potential is great" (ibid: 110).

A recent self-evaluation exercise conducted in the first-year History course at the University of Zululand produced results that were in keeping with Boud's research (1990) on self-assessment: it gave students the opportunity to think critically about what they learnt as well as the opportunity to evaluate how well they had learnt it. This research also confirmed previous findings by Boud (1990), that students do not come to tertiary education with well-refined self-evaluative skills: they need to be guided in the

process. (For a more comprehensive discussion of this research, see Sutherland 1997).

In order to facilitate the development of life-long learners, assessment tasks need to be designed that encourage the development of critical self-reflection and self-evaluation. The assessment design should not accommodate the educator as the sole judge of worth. The keeping of learning log-books and journals is one way of encouraging reflective practice for both educators and learners. Similarly, encouraging learners to write about the muddiest point of a section of work (in other words a section about which they are most unsure) often heightens their understanding of the topic.

THE USE OF ASSIGNMENT ATTACHMENTS WHICH IDENTIFY ASSESSMENT CRITERIA

This assessment technique is a well-known but under-utilised one. When students are provided with a task for assessment purposes, a list of criteria by which students will be assessed, can be supplied to students prior to the task being submitted for assessment. This "form" is then submitted together with the task for the purpose of assessment. The use of such a "form" has the two-fold advantage of familiarising learners with the criteria by which they will be assessed and reducing the amount of time spent on providing meaningful feedback to learners. With the use of this kind of attachment, the evaluation of work by fellow students can also be facilitated. In addition, the development of such a form could be the first step in negotiating consensus between the educator and the learners with regard to criteria by which evidence of successful learning can be gathered.

USING AUTHENTIC ASSESSMENT PRACTICES

Such assessment requires the learner to perform real-life tasks. For example, learners of History should be required to act in a way in which Historians do. Authentic assessment practice means that there is no significant gap between the assessment task and what happens in the world of work. The SAQA Bulletin of 1997 (p 15), makes mention of assessment methods such as portfolios, simulations and in situ work-place assessments. The assessment design needs to use assessment contexts that are likely to be encountered by students in real-life situations. Research in the area of "open book testing" shows that staff and students are enthusiastic about the opportunities given students to analyse and synthe-

size information under "real-world" conditions (see for example Candy 1994: 151).

While authentic assessment tasks does not obviate the need to make an assessment, it nevertheless places the focus of the assessment on learning, rather than on the measurement of learning. The use of portfolio assessment, which requires that students submit a number of pieces of writing in order to demonstrate a progression in their development, is both developmental and formative. It can reduce the workload of administration, while maintaining a positive effect. (Much time is usually spent on the collection and return of individual pieces of writing for the purposes of assigning a number of individual marks in isolation of any other writing.) Portfolio assessment reduces the time taken for collection and return of work, as students submit a number of pieces of writing written over a period of time, at one time. (Feedback to students might have taken a variety of forms during this process.) The assessment of such portfolios should depend to some extent on the personal development demonstrated in the learners'

cognitive understanding of the topic (ipsative or self-referenced assessment).

CONCLUSIONS

In order to adapt existing practices to the new paradigm suggested by SAQA, a shift in the conception of teaching and learning is necessary. We believe that this shift in practice will enhance the capacity of learners on a life-long path to learning. To maximize the positive effects of assessment in the face of ever-decreasing resources, it has become necessary for staff to review their assessment practices. Educators need to acknowledge that assessment is based on human judgement and not pretend that it is an accurate, rigorous, objective and scientific exercise (Luckett 1995). Although technology will play an increasingly important role in education in the future, involving the learning in the process of assessment remains an effective way of fostering deep approaches to learning. In order to achieve the noble goal of life-long learning, students need to be guided in making assessments of the worth of their own work.

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Pressure Measurements: A Diagrammatic Comparison

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Pressure Measurements: A Diagrammatic Comparison

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High-school physics and chemistry texts refer routinely to various types of pressure—atmospheric or barometric pressure, gauge pressure, and absolute pressures. To complicate matters further, pressure measurements may be obtained using a variety of instruments or, in some cases, combinations of instruments: mercury and aneroid barometers; open-end and closed-end manometers; tire gauges; and so on.

In a student's mind this often creates the idea that there are a number of different kinds of pressure, just as there are a number of different kinds of energy. Although pressure may be measured in various ways, expressed in different units, and called by several names, these are all, nevertheless, expressions of the same physical phenomenon, and it is important to make it clear to students that there is only *one* type of pressure.

In many cases, the prevailing atmospheric pressure is used as a starting point for other pressure measurements. The prevailing atmospheric pressure varies with place and time due to changes in temperature, humidity, altitude, etc. For this reason, it is necessary to distinguish clearly between atmospheric pressure (a variable) and the numerical value of the standard atmosphere, which has a constant value of 101,325 Pa (760 mm Hg).

A discussion of pressure and its measurement is typically introduced just prior to the section about the ideal gas laws and usually involves an account of the barometer and the manometer.

The basic principles underlying

the barometer and the open-end manometer are adequately described in most relevant textbooks and include diagrams such as Fig. 1. Despite this, it is not always apparent to students why the manometer reading is sometimes subtracted from and sometimes added to the value of the atmospheric pressure. It is at this stage that we try to clarify the situation for our students by making use of the diagram shown in Fig. 2.

The first arrow, P_1 , represents the atmospheric pressure, A , that may be

measured using a barometer as shown in Fig. 1a. The second arrow, P_2 , represents a pressure *greater* than atmospheric pressure. It is clear from the diagram that $P_2 = A + B$. Thus P_2 may be measured by reading the atmospheric pressure, A , and then *adding* the open-end manometer reading, B (Fig. 1b). The third arrow, P_3 , represents a pressure *less* than atmospheric pressure. Again, it is clear from the diagram that $P_3 = A - C$. Thus P_3 may be measured by *subtracting* the open-end manometer

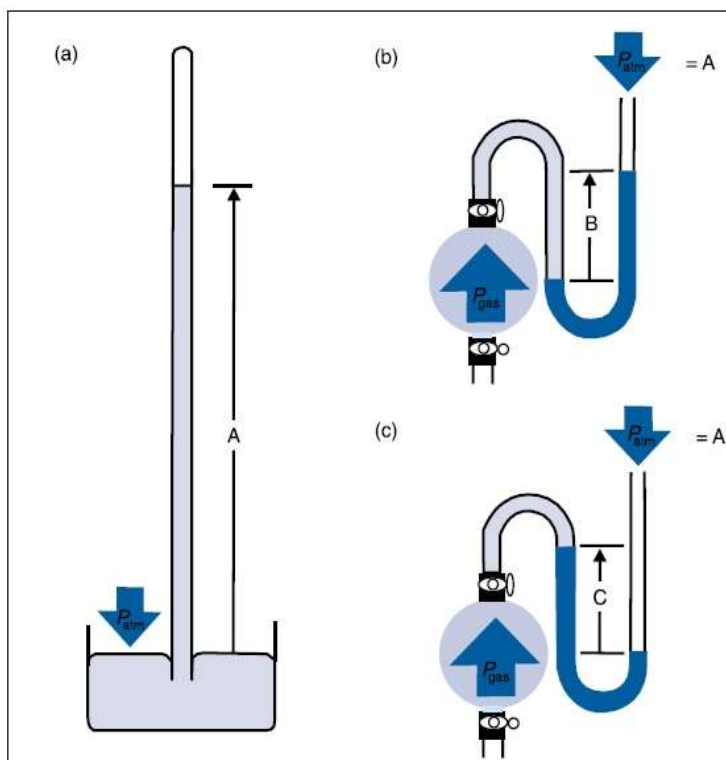


Fig. 1. (a) Use of a barometer to measure atmospheric pressure, A .
(b) Use of an open-end manometer to measure a gas pressure greater than atmospheric pressure. $P_{\text{gas}} = A + B$.
(c) Use of an open-end manometer to measure a gas pressure less than atmospheric pressure. $P_{\text{gas}} = A - C$.

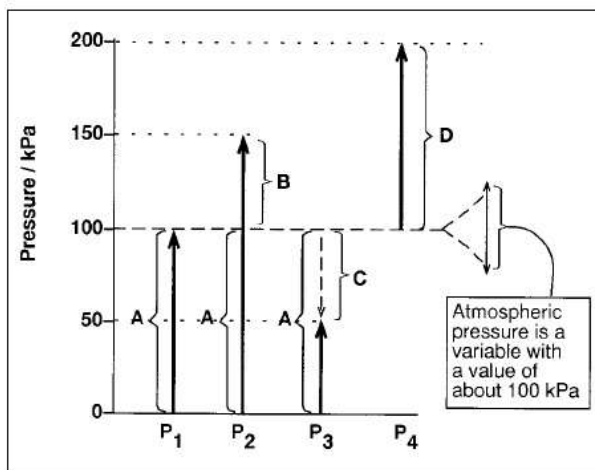


Fig. 2. $P_1 = A$ = atmospheric pressure
 $P_2 = A+B$ = a pressure greater than atmospheric pressure
 $P_3 = A-C$ = a pressure less than atmospheric pressure
 $P_4 = D$ = gauge pressure as read on a "tire gauge."

reading, C (Fig. 1c) from the atmospheric pressure, A.

Gauge pressure is represented by the final arrow, P_4 , and is often poorly understood by students. It helps to suggest that a tire gauge gives the same type of reading as an open-end manometer, the difference being that a tire gauge can only read pressures

greater than atmospheric pressure. The reading, D, obtained from a tire gauge is then understood from Fig. 2 to be the amount by which the measured pressure exceeds the prevailing atmospheric pressure.

If the atmospheric pressure, A, were added to the gauge pressure, D, then an "absolute" pressure would be

obtained. The gauge pressure in car tires is typically about twice the atmospheric pressure, i.e., about 200 kPa, (30 lb/in²), hence the "absolute" pressure in such a tire is about 300 kPa (45 lb/in²). When a tire is completely "flat" the pressures inside and outside the tire are the same, and are both equal to the prevailing atmospheric pressure. In such a case the gauge pressure reading will be zero, but an "absolute" pressure of about 100 kPa (15 lb/in²) will still remain in the tire.

Sometimes students ask whether a vacuum is a "type" of pressure. We point out that a vacuum is simply the name given to any pressure that has a value that is substantially lower than normal atmospheric pressure. In Fig. 2, an arrow similar to P_3 would represent a vacuum. It would usually have a much smaller magnitude than P_3 , but the principles would be the same.

We have found that the use of Fig. 2, in addition to the diagrams commonly found in textbooks (Fig. 1), makes many of the concepts involved in pressure measurement easier for our students to understand.

et cetera...

The Origins of the College

"What printing the Gutenberg Bible did was to make universal literacy possible. Prior to printing, the word was written, but it was written in longhand and was unbelievably rare and expensive. Every book up to four hundred years ago was written by hand, and it took a college boy four, five, six, seven, eight years of taking courses at the University of Bologna in Italy to acquire one copy in his own longhand of Aristotle's *Poetics* or *Politics*. In fact, the word *college* entered the language as a labor union against professors. It was a collegium of students forcing professors to read their copy of their book so slowly that one could get his own copy by taking a course no more than four times. If you had a copy of a book, you were a professor and you ran around reading your copy. You may have noticed that this is still going on." ^{1,2}

1. T. Adams and B. Brandenburg: *Higman: A Collection* (Thomas-Berryhill Press, Lafayette, CA 1998), p. 122.

2. The late Howard Higman, Professor of Sociology at the University of Colorado in Boulder, was a close friend and colleague since 1969.

A²B

The role of self assessment in moderating students' expectations

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ABSTRACT

This preliminary study investigates relationships between students' expectations before an assessment, their *in situ* assessment of their own performance and the evaluations made by the lecturer. Most recently, it has been widely accepted by academics that self assessment and self monitoring has a valuable role to play in the learning process. Does self assessment play a role in the moderation of student expectations? The results of this study show that while there is a high correlation between the students' *final* assessment of their own performance and that of the lecturer, the students do not have an innate ability to assess their own performance reliably – training and practice is necessary. It is however clear that the use of self assessment is an extremely effective way of moderating students' expectations which are often unrealistically higher than their performance.

rate, a comprehensive course evaluation was conducted by the lecturer, and the following two salient points emerged:

- Few students continue to second year Chemistry as the failure rate in second year Chemistry is believed to be much higher than that in a number of other Departments which are regarded by students as "soft options".
- Despite high ratings for all other aspects of the course and for the lecturer's performance, students expressed strong dissatisfaction with regard to the lecturer's marking of tests and examinations. They felt that the test and examination papers were being marked "far too strictly".

It is this second point that is the focus of this article. A study involving self assessment was conducted to evaluate students' perceptions with regard to the mark allocation process. In addition, students' expectations of their own worth were investigated as possible contributing factors to this obvious dissatisfaction.

INTRODUCTION

Concerns about the course

This study was initiated in response to the high attrition rate in many first year courses at the University of Zululand. Because the problem is particularly severe in the Chemistry Department, it was decided to use this department as a pilot study.

Each year, an average of about 150 students enrol for the first year course in Chemistry and yet only about a 10% of these students continue with the course in the second year. This is despite the fact that the pass rate for the first year course is about 60%.

First year Chemistry is a pre-requisite for several other courses. This is a partial, but not sufficient explanation for the low numbers continuing to second year Chemistry. As a result of concern about this drop out

The role of self-assessment in the learning process

Most recently, through the work of people like Boud (1989), Gibbs (1995) and others, it has been widely accepted by academics that self assessment and self monitoring has a valuable role to play in the learning process. Boud (*ibid*:21) states that self assessment has also been accepted as the key to establishing a process of life long learning and therefore needs to be encouraged. Among the pedagogical benefits is that the use of self assessment provides students with an opportunity to take ownership of the criteria (Wiggins 1992). As Klenowski (1995:145) points out, "It provides students with opportunities to take increased responsibility for, and a more active role in, their own learning".

The use of self assessment as a formative kind of

assessment (in other words as a means of providing students with feedback to their learning) has for some time been used constructively to promote learning. The use of self assessment for summative purposes (in other words for educational decision making) is however a much more controversial issue. Kwan and Leung (1996:206) point out that one of the main obstacles to a wider introduction of self assessment into the educational process is the belief that student derived marks could not be used in formal grading procedures because they would not be accurate enough. Our study shows that this widely held belief is not necessarily valid.

The value of authentic evaluative experience, such as this study, is discussed by Klenowski (1995:151) who, citing Sadler (1989) argues that if teachers provide students with this type of assessment experience, then the students are more likely to develop the ability to become independent and fully self monitoring. Students report that self assessment is empowering by the way in which it signals to students that their experiences are valued and their judgements are respected (Kwan & Leung 1996:206). It is also widely recognised that one of the important goals of higher education is to develop students into "reflective practitioners" who are able to reflect critically on their own practice (Kwan & Leung 1996:205).

Aims of study

This preliminary study attempts to investigate relationships between students' expectations before an assessment, their in situ assessment of their performance (self assessment) and the evaluations made by the lecturer. The question guiding the process was the following: Does self assessment play a role in the moderating of student expectations? The study is an attempt to align student expectations with realistic assessments of their own worth.

The natural progression of this research would be to ascertain how the process of self assessment in the moderating of student expectations was experienced by the students themselves. Collaborative approaches to research need to take account of student perspectives as well as those of staff (Boud 1989:28).

METHOD

The evaluation was designed around one of the two official semester tests conducted in the Department of Chemistry. One of the 11 students registered for the course declined to participate in the process. Im-

mediately prior to the test, students were asked to provide a realistic estimate of the mark that they felt would be a fair estimation of their current state of preparedness for the test. In an attempt to minimise unrealistic expectations, students were given considerable guidance in this matter. For example, they were advised to take into account:

- The amount of work they had done in preparation for the test.
- The number of end of chapter questions and problems they had worked through in their text book.
- Their success or otherwise in answering these problems, for which answers had been provided by the lecturer.
- Their level of success in answering questions from copies of the past three years' examination papers that had been provided by the lecturer as practice exercises, complete with detailed model answers.
- Finally they were reminded to give an estimate that would reflect what they *deserved* for the test, *on the basis of the quantity and quality of the preparation that they had made*, rather than an estimate of what they *hoped* to obtain. These pre test estimates are listed in column (A) of the Table.

Immediately after the test had been written, the students were asked to give a revised estimate of their expectations now that they had actually written the test. These post test estimates are listed in column (B) of the Table.

The following day students were each provided with a photocopy of their own answer script and a detailed model answer drawn up by the lecturer. They were asked to mark their own scripts using the model answer as a guide, and allocating themselves what ever marks *they* felt would be a fair reflection of the answers that they had given. The test included both numerical calculations and mini essay or paragraph type questions. The model answer gave the *total* number of marks for each question, but gave *no indication* of how these marks were to be allocated within each question. This was done deliberately in order to give students the latitude to allocate themselves as many marks as *they* thought were reasonable for any incomplete or partially incorrect answers. The results of this self assessment are given in column (C) of the Table. Finally, the lecturer marked the original scripts according to his own, much criticised standards. These results are listed in column (D) of the Table.

RESULTS

Table 1
The results of the self-evaluation process

Student number	A	B	C	D
	Pre test estimate	Post test estimate	Self assessment	Lecturer's mark
1	70	55	34	32
2	65	38	45	40
3	70	57	68	66
4	60	40	33	28
5	65	40	36	35
6	70	45	35	31
7	60	50	52	62
8	86	40	32	26
9	70	17	32	35
10	68	50	50	51
$r(AB) = -0,08$ $r(BC) = +0,57$ $r(CD) = +0,95$				

DISCUSSION

It is clear from the pre test estimates, that despite all the guidance that was given, students still maintained substantially inflated estimates of their own abilities. The estimates provided in the post test estimate were more realistic, ie lower, but there was no correlation whatsoever ($r = -0,08$) between these two estimates. There was no significant correlation ($r = 0,57$) between the students' post test estimate and their self assessment using the model answer. However, there was a particularly strong correlation ($r = 0,95$) between the students' self assessment and that of the lecturer.

The large differences between the students' pre test estimates and their actual performance suggests that students need more training in estimating their performance. This view is supported by the work of Gibbs (1995) who states explicitly that students do not come to higher education with the innate ability to assess their own performance reliably. They need practice and training in order to develop this judgement. In "inability" to judge their own worth is often particularly characteristic of second language learners (as the majority of our students are), who prefer to measure the worth through the reflections of others. For this and other reasons, students need to be

convinced of the value and validity of their self assessment process (ibid).

The high correlation between the students' evaluation of their own performance and the lecturer's assessment, shows that students were able to assess their own worth with remarkable accuracy provided they were offered correct and sufficient guidance in the assessment process. Given the educational background of "disadvantage" from which our students come to the university, the opportunity to critique their own work is both a new and cathartic experience for many. (For a comprehensive discussion of other work done at the University of Zululand in this regard, see Sutherland 1997).

CONCLUSIONS

The data makes it clear that the use of self assessment is an extremely effective way of moderating students' expectations which are often unrealistically higher than their performance. These high expectations might account for their initial dissatisfaction with the way in which tests and examinations are marked. Further research in this context might show that students express greater satisfaction with the assess

ment process once they take ownership of the criteria and become involved in the process.

The following conclusions can also be drawn at this stage of the research. Later research will investigate whether these are valid conclusions to draw about assessment.

1. Self assessment can be an extremely reliable means of assessment. The data even suggests that it is possible to use self assessment in this context for summative purposes, bearing in mind that there are often large discrepancies between the marks awarded by different assessors, regardless of their academic status.
2. In the detailed model answer supplied to students, they were given the total number of marks for each question but the mark allocation within each question was deliberately not given. Even with this latitude, that data shows an excellent correlation between the student evaluation and that of the staff member. It is our thesis that, had the mark allocation within each question been given, the correlation would have been even better.
3. The data shows that students' initial expectations were not realistic, but after they were given guidance and a model answer their own evaluation of their work became more reliable.

4. Student dissatisfaction might arise out of ignorance of the process of assessment and the ways in which criteria are applied.
5. Future assessment practices need to consider student evaluations in a more direct manner. As Boud (1989:22) points out, "if there is a high correlation between marks generated by students and those generated by staff, why bother with involving students if their contribution makes no difference to the final grades?" Learning has to move from being teacher directed to being student directed.

While this exercise does not appear to have alleviated students' dissatisfaction with the overall outcome of the assessment process, it has nevertheless provided them with the opportunity to evaluate themselves in an authentic manner and thus proved to be a useful learning experience. Although this study was conducted in a Chemistry class, the findings are supported by research in other disciplines which indicates that students are able to make reliable judgements of their own worth, given the correct guidance and support (see Gibbs (1995) and Nightingale (1988)). If tertiary institutions in South Africa hope to produce life long learners, educators must heed the call to assist their students in becoming self directed learners.

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The research output of female academics at a South African university: Progress with gender equity?

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Abstract

Two pressing demands directed to the South African academy in the post 1994 environment, have been those of gender equity and of increasing research output. The progression of women to the higher academic ranks is a problem, not only in South Africa, but worldwide. In view of the importance attached to research output for purposes of academic promotion, raising the research output of female academics is therefore important beyond the reason of being an end in itself. This paper is a case study at one university of the intersection between these two issues. The aim is to assess the improvement of the research output of female academic members of staff relative to their male counterparts, in the post 1994 period. The data used in the study indicate a steady increase in the research output of female academics relative to their male counterparts. However, a significant gender discrepancy in this regards still remains. In conclusion some suggestions are made with regard to how to an increase in the research output of female academics may be facilitated.

Introduction

Since the late 1960s, higher education worldwide has been undergoing a series of transformations. By the end of the twentieth century, the traditional university, characterised by its research and teaching functions, academic

autonomy, elitist ethos and substantial state financing, came under pressure from a combination of societal trends. These trends included the drive for equal educational opportunities, democratisation (massification), the neo-liberal economic revolution (global acceptances of the capitalist or free market system, managerialism, performativity, productivity), globalisation and globalism (Steger 2009, 98ff.), as well as the technological revolution (Steyn and Wolhuter 2008,13-33).

The international boycotts against South Africa (c. 1960-1990) resulted in its universities remaining relatively isolated from the changes which affected universities elsewhere in the world (Wolhuter and Higgs, 2006). However, after the advent of the new socio-political dispensation in 1994 and South Africa's re-incorporation into the international mainstream, its entire academic environment was exposed to these changes, not gradually as elsewhere in the world, but intensely and rapidly (Adams 2006; Bundy 2005; Ntshoe 2004; Jansen 2004; Waghid, Berkhout, Taylor and De Klerk 2005; Webster and Mosoetsa, 2002).

Two pressing demands that South African academia had to cope with in the post 1994 environment, like universities elsewhere in the world, were those of gender equity and increasing research output (Bundy 2005; Coates, Goedgebuure, Van der Lee and Meek 2008; Galaz-Fontes, Padilla-Gonzales, Gil-Antón, Sevilla-Garcia, Arcos-Vega, Martinize-Stac, Martinez-Romo, Sánchez-De-Aparicio-y-Benitez, Jiménez-Lozd Barrera-Bustillos L and Barrera-Bustillos ME; Kruss 2008 and Locke 2009). This paper reports on a case study done at one South African university about the intersection between these two issues. The aim of the research project was to assess the improvement of the research output of female academics *vis-à-vis* that of their male counterparts, in the post 1994 period.

Firstly, the contextual background is portrayed, i.e. the world-wide transformation of higher education since the 1960s, the transformation of higher education in South Africa since the early 1990s, the demands for greater gender equity and increased research output in South African higher education institutions, and the position regarding all of these at the University of Zululand (UZ) (the locale of this case study). This is followed by an outline of the research method and presentation of the findings. A number of conclusions are then drawn from the findings, followed by some suggestions.

Contextual background

Since the late 1960s, higher education worldwide has been caught up in a maelstrom of societal developments. These developments include population

explosions in various parts of the world, advances in technology, communication and information, globalisation and globalism, multiculturalism, democratisation (massification), the demise of the nation state, economic liberalism (capitalism; rise of the free market system) and privatisation (Wollhuter 2007, *passim*).

The summative effect of these developments has been the persistent erosion of the traditional view of the university. This view, which Schugurensky (1999) calls the “academic haven” (sometimes referred to as the “ivory tower” view), is characterised by research and teaching as the twin functions of the university, academic autonomy (freedom of research, teaching and learning), an elitist ethos and substantial state funding.

The socio-political drive for equal opportunities which became the dominant driving force behind education reform during the second half of the twentieth century worldwide (Cooper 1980, 1) also had an impact on higher education. The roots of this driving force are, amongst others, the insistence on democratisation, the recognition of human rights and the impact of human capital theory (Brezinka, as quoted by Engelbrecht and Nieuwenhuis 1988). The drive for equal opportunities necessitated moving away from an elitist to a more egalitarian model, not only with respect to access and equity but also regarding staffing in terms of gender (Lapidus 1982, 254), socio-economic origin, and social and ethnic background (World Bank 2002). Resultantly, gender equity has become internationally a dominant motive in higher education (see Bain and Cummings 2000; Farrell 1999, 152-157; Silova and Magno 2004; Welch, 1997). While significant strides have been made in recent decades regarding enrolment of female students at institutions of higher education and in the employment of female academics, the relatively small number of female academics progressing towards the higher academic ranks remains a cause for concern. Bain and Cummings (2000) analysed the data of the fourteen countries and one administrative region that formed part of the Carnegie International Investigation of the Academic Profession (the United States of America, Canada, Mexico, Chili, England, the Netherlands, Sweden, Germany, Russia, Israel, Japan, Hong Kong, South Korea and Australia) as well as those of several other countries and found this to be a consistent problem. A study of ten national higher education systems revealed that although women constituted one-third of all academics, only one in ten progressed to the rank of full professor (Bain and Cummings 2000: 493). This “glass ceiling” that females apparently encounter in their efforts to progress in their careers is, however, not limited to the academic profession. In corporate America, despite the fact that 40% of all managerial workers are women, only 5% of them were appointed to senior management levels (Bain and Cummings 2000: 493).

The neo-liberal economic revolution (global acceptance of the capitalist or free market system) also represents a societal development that has been affecting universities (see Higgs 2006). Academic autonomy is increasingly being eroded as business principles such as accountability, quality control, managerialism, performativity and profitability are applied in the running of universities, and as governments (as the main sources of funds for most universities) appropriate an ever greater say in the internal affairs of universities. Government funding tends to be tied to performance targets, amongst others research output. The curtailment of university autonomy has also been a common phenomenon in the history of universities in Africa during the post 1960s' decolonisation period, a trend characterised by governments taking steps to ensure that their wishes were carried out by harnessing universities to the achievement of their political objectives. To this end, governments, as the main sources of funds for most universities, assumed ever more say in the affairs of the universities (Wolhuter and Higgs 2006). This tends to impinge on the academic autonomy of institutions of higher education in that business principles such as accountability, quality control, managerialism, performativity and profitability are applied to their management (Higgs, Ntshoe, Potgieter, Van der Walt and Wolhuter 2010, 6). The problem of gender equity and concomitant research output at universities in general, but more specifically in South Africa, should be viewed against this culturo-historical background (see Bornstein 1988; Coombs 1985; Lapidus 1982:228, 254).

The project reported in this article revolved around the issue of gender equity in academic staffing in relationship to the research output of a particular South African university.

For some three decades, c. 1960-1990, South African universities were subjected to a boycott by the international higher education community as part of the international isolation of South Africa at that time (see Harricombe and Lancaster, 1995). The result was that South African universities were for a long time relatively unaffected by developments in universities elsewhere in the world. When South Africa re-joined the international community after 1994, its universities were resultantly significantly out of step with international trends.

According to Truscott (1994, 4), relations between people in South African society were characterised by inequality along the lines of class, race and gender. Gender inequality was another common feature of the South African higher education scene (see Bain and Cummings, 2000). At the Potchefstroom University (as the institution was known up to 2004) salary parity between male and female academics was, for example, only achieved in 1979. Until

1980, married female academics enjoyed the official status of temporary staff (Du Pisani 2006, 203).

Traditionally, South African education, including South African higher education, had all the characteristics of inequality mentioned above, including gender inequality. In contrast, the post 1994 education dispensation was built upon the principle of equality, democratisation and multiculturalism (see Wolhuter 1999, 366). Furthermore, the entire education system was expected to contribute to the socio-economic reconstruction and development of the country (see Wolhuter 1999). Application of these principles implied that equity considerations became important in the recruitment of staff and students, amongst others, in terms of gender (Fourie 1999). The issue of gender inequality in South African society has featured prominently in the post 1994 era (see Bhoola 1996; Flood 1998; Gouws 2010, 8; Kadalie 1995; Kethusegile 2000; Tshoaedi 1998). In contrast with the attention given to racial equality in the political programme and in education research agendas, gender issues and gender inequality have not featured to the same extent (see Wolhuter, 1994). The same applies in the case of Higher Education research (see Deacon, Osman and Buchler 2009; Wolhuter, 1997). After comparing the agenda of Comparative Education research in South Africa with that of educationists abroad, Wolhuter (1994) noticed that while gender issues in education were afforded top priority in research abroad, it was totally absent from the research agenda of comparative educationists in South Africa.

The same applied in the case of higher education research (Wolhuter 1997). Indicative of the problem is the fact that research such as those of Olivier (2005) on job-related stress in the South African academic profession, Olivier, De Jager, Grootboom and Tokota (2005) research on the work wellness of academics in higher education institutions in South Africa, and Schulze's (2006) on factors influencing job satisfaction of academics in higher education in South Africa deal only with aggregate figures and not with data broken down or analysed in terms of gender. In addition to this, the few published research papers on gender equity in higher education in South Africa arrived at contradicting conclusions. For instance, based on their application of the questionnaire of the Carnegie International Investigation of the Academic Profession (see Altbach, ed. 1996) to a sample of South African academic professionals, Higgs, Higgs and Wolhuter (2004) concluded that a surprising measure of gender equality existed in the South African academic profession. Research by Mabokela and Mawila (2004) and Mickelson, Nkomo and Smith (2001), on the other hand, arrived at a different conclusion. Based on semi-structured interviews with 20

Black women academics at five institutions of higher education in South Africa, they inferred that the following forms of gender inequality were still plaguing the system: the lack of mentorship available to women academics; the persistent existence of broader societal norms and values that influence male and female relationships to the detriment of female academics; organisational practices and policies which were still male-dominated and which marginalised “women’s ways of knowing and doing” and how all of these impact on interethnic and interracial relationships and interactions on campus.

In Mickelson *et al.*’s (2001) historico-comparative study of South Africa and Israel, it emerged that in both countries disparities existed in the educational attainment of males and females and in the income for similarly qualified members of both genders among all racial groups. Boshoff’s (2005) analysis of data regarding the representation of women in the academic profession in South Africa revealed that while the percentage of women academics increased significantly in the years before this study, women were still under-represented in the upper academic ranks. This confirmed Zulu’s (2003) findings. Schulze’s (2005) investigation into the job satisfaction of black female academics at a South African university revealed that her respondents thought that if they could increase their research output, their levels of job satisfaction would also increase. The respondents indicated that the two pressing problems that prevented them from attaining this goal were a lack of time and of research expertise.

Universities in South Africa have traditionally been conceptualised as teaching and training institutions, with research occupying a subordinate role (see Sutherland & Wolhuter 2002, 79). The profile of South African institutions of higher learning was traditionally moulded on the perceived need to train human resources for a developing economy (Jansen 2009, 3). Writing in the mid-twentieth century, Smith (1956, 16), who became famous for his pioneering research on the coelacanth, states the following:

Research at South African universities has occupied a subordinate, and in some ways uneasy, position. University staffs are normally appointed and paid for teaching, and while research is officially recognised, anyone who devotes more than normal time to such work runs the risk of being regarded as not giving proper attention to the teaching for which he (*sic*) is being paid.

Amidst many sceptical opinions about the possibility of the university as purely a research institution (e.g. see Feldman, 1987, 275) Barnett (1992), contends that research has, nevertheless, become the fulcrum of the contemporary academic community. The status of research at South African universities

has changed as a result of a new subsidy-formula, introduced in 1984, which links government grants to research output. Measured against the international norm, the research output of South African academics is low (Wolhuter, Higgs and Higgs 2006, 11-12). In the research (referred to above) based on the questionnaire of the Carnegie International Investigation into the Academic Profession, South African academics' average response to the question as to how many articles respondents had published in an academic book or journal during the three year period before the survey, was 3.65; the comparable figure for Japan was 6.7 (Arimoto 1996, 164) and for the Netherlands 7.1 (Geerts, Massen and Van der Vught 1996, 515). By 2004, the research output of the historically Black South African universities was still lower than that of the historically White universities (Gilmour, 2001; Wolhuter, Naidoo, Sutherland and Peckham, 2003/4).

Against this background, a project was launched at a historically Black university in South Africa to establish the degree to which gender equity had taken place in terms of research output.

Research method

In order to establish the degree to which gender equity had taken place in terms of research output at UZ, the following were calculated:

- (1) the research output (measured in South African Post Secondary Education (SAPSE) units) aggregate, per faculty and per gender,
- (2) the academic staff numbers, per faculty per gender, and ,
- (3) the average research output per person per faculty and per gender per year.

These data were determined for each of three time periods.

- (1) the ten year period 1985 to 1994 under the old constitution,
- (2) the ten year period 1995 to 2004 under the new constitution, and
- (3) the next six year period 2005 to 2010

The post 1994 data were divided into two periods (as indicated above) to allow for the likelihood that the effects of gender equity promoted in the new constitution were likely to experience a time lag before their effects (hopefully) became apparent.

Results

The total research output of academic staff in SAPSE units per person per year is presented in Table 1. Compared to the pre-1994 period with a the research output of 0.101 units per person per year, the output in the 16 year post-1994 period more than doubled to about 0.225 units per person per year. This overall improvement conceals the fact that the output of females increased more than that of males as will be illustrated in the next table.

Table 1: Total output of SAPSE papers per person per year

PERIOD	ITEM	TOTALS
Ten Years 1985-1994	SAPSE Units	268.05
	Staff Numbers	266
	Units per person per year	0.101
Ten Years 1995-2004	SAPSE Units	509.24
	Staff Numbers	225
	Units per person per year	0.226
Six Years 2005-2010	SAPSE Units	338.77
	Staff Numbers	252
	Units per person per year	0.224

The research output of academic staff in SAPSE units per person per year is presented in Table 2 by faculty and gender. This Table illustrates that gender ratios in staff numbers and in research output deviate from equity across the board with some faculties being significantly worse than others. However, it is the overall institutional gender equity that is of greater initial concern.

The “Totals” column in Table 2 shows that during the pre-1994 period the research output of males was 0.123 units per person per year. This output increased significantly to 0.294 units per person per year in the ten years following 1994 but then eased back to 0.269 units per person per year during the following six years. During the pre-1994 period the research output of females was 0.046 units per person per year. As with their male counterparts, this output increased significantly to 0.118 units per person per year in the ten years following 1994 but, unlike their male counterparts, females maintained this progress and improved their output further to 0.151 units per person per year during the following six years.

The overall result of these trends is that in the ten year pre-1994 period, females produced one SAPSE unit for every 2.7 produced by their male counterparts. Despite the constitutional changes in favour of gender equity, the ten year post-1994 period showed only marginal improvement with females producing one SAPSE unit for every 2.5 produced by their male counterparts. However, the following six year period (2005 – 2010) showed a dramatic improvement in research output equity with females now producing one SAPSE unit for every 1.8 produced by their male counterparts. It would seem that, despite the existence of a time lag, gender equity policies are finally starting to yield results. Unfortunately there is still a long way to go since, despite the recent significant gains, the research output of female academics is still barely half of that of their male counterparts.

To facilitate comparisons, some of the data from Table 2 has been presented as percentages in Table 3.

P. T. O.

Table 2: SAPSE Publications of University of Zululand—absolute numbers

PERIOD	FACULTIES	ARTS & THEOLOGY		SCIENCE		LAW & COMMERCE		EDUCATION		TOTALS		RATIO OF TOTALS
		Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	
Ten Years 1985-1994	UNITS											Female: Male
	SAPSE Units	24.50	100.50	9.75	97.75	0	31.05	2.00	2.50	36.25	231.80	1 : 6.4 ^(a)
	Staff Numbers	42	79	10	44	3	29	23	36	78	188	1 : 2.4 ^(b)
Ten Years 1955-2004	Units per person per yr.	0.058	0.127	0.098	0.222	0.000	0.107	0.009	0.007	0.046	0.123	1 : 2.7 ^(c)
	SAPSE Units	68.69	166.78	22.83	203.89	0	23.67	11.33	12.05	102.85	406.39	1 : 4.0 ^(a)
	Staff Numbers	36	48	23	45	5	23	23	22	87	138	1 : 1.6 ^(b)
Six Years 2005-2010	Units per person per yr.	0.191	0.347	0.099	0.453	0.000	0.103	0.049	0.055	0.118	0.294	1 : 2.5 ^(c)
	SAPSE Units	50.18	110.78	21.64	120.82	6.18	16.17	10.17	2.83	88.17	250.60	1 : 2.8 ^(a)
	Staff Numbers	30	47	32	56	15	30	20	22	97	155	1 : 1.6 ^(b)
	Units per person per yr.	0.279	0.393	0.113	0.360	0.069	0.090	0.085	0.021	0.151	0.269	1 : 1.8 ^(c)

(Male and female academic staff numbers were taken as officially recorded at the end of each period i.e. 1994, 2004 and 2010 respectively).

For the final ratios (c) = (a) / (b)

Table 3: SAPSE Publications of University of Zululand – percentages

PERIOD	FACULTIES		ARTS & THEOLOGY		SCIENCE		LAW & COMMERCE		EDUCATION		TOTALS	
	UNITS		Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
Ten Years 1985-1994	SAPSE Units		19.6	80.4	9.1	90.9	0	100	44.4	55.6	13.5	86.5
	Staff Numbers		34.7	65.3	18.5	81.5	9.4	90.6	39.0	61.0	29.3	70.7
Ten Years 1955-2004	SAPSE Units		29.2	70.8	10.1	89.9	0	100	48.5	51.5	20.2	79.8
	Staff Numbers		42.9	57.1	33.8	66.2	17.9	82.1	51.1	48.9	38.7	61.3
Six Years 2005-2010	SAPSE Units		31.2	68.8	15.2	84.8	27.7	72.3	78.2	21.8	26.0	74.0
	Staff Numbers		39.0	61.0	36.4	63.6	33.3	66.7	47.6	52.4	38.5	61.6

A possible explanation for the fact that the research output of female staff is still lagging behind that of their male counterparts may lie in the fact that the improved gender ratios of UNIZUL members of staff have largely been achieved by the recruitment of females who were relatively under-qualified compared to their male counterparts. This discrepancy is reflected in the Table 4.

Table 4: Qualifications of academic staff at the University of Zululand

	Ten Years 1985 - 1994		Ten Years 1995 - 2004		Six Years 2005 - 2010	
	Female	Male	Female	Male	Female	Male
Total Number of Staff	78	188	87	138	97	155
Number of Staff with PhDs	9	54	13	63	29	61
% of Staff with PhDs	12	29	15	45	30	39
SAPSE units per person per year	0.046	0.123	0.118	0.294	0.151	0.269

The research output of females increases steadily as the percentage of females with Ph Ds increases over the entire 26 year period. The research output of males increases with an increase in Ph Ds from the first to the second 10 year period and then decreases in line with a decrease in the percentage of male staff with Ph Ds for the following six year period. The implication is that research output is closely tied to the percentage of staff with Ph Ds. If equity is to be obtained in the research output of females, then it is necessary not only to achieve gender equity in staff numbers but attention should also be paid to increasing the percentage of female staff with PH Ds.

These results seem to form part of a national trend that might be explained as follows. The application of the questionnaire of the Carnegie International Investigation of the Academic Profession to a sample of the South African academic profession (referred to above) indicated that the average age of male and female South African respondents at that time were 43.6 and 43.2 years respectively (Wolhuter, Higgs and Higgs 2007). Male and female respondents had, however, been employed in higher education for an average of 13.8 and 9.8 years respectively. South African higher education institutions distinguish between the following academic ranks: junior lecturer, lecturer, senior lecturer, associate professor and (full) professor. The questionnaire accorded

the numbers 1 to 5 to these ranks respectively and added another category, namely for respondents in management positions. The average male response was 3.9 (somewhere between senior lecturer and associate professor), while the average female response was 2.8 (somewhere between lecturer and senior lecturer) (Wolhuter *et al.* 2007).

The above-mentioned data show that the South African academic profession displays a relatively young profile. The proportion of female academic members of staff is comparatively high. In the other countries in which the survey was conducted the percentage of male faculty ranged from 60% in Brazil to over 90% in Korea and Japan (Altbach and Lewis 1996).

In the other countries in which the survey was conducted, the average ages of faculty were as follows: Mexico: 39.2 (Antón 1996); Netherlands: 42.3 (Geerts *et al.* 1996); Korea: 44.8 (Lee 1996); Australia: 45 (Sheehan and Welch 1996); England: 47 (Fulton 1996); and United States of America: 48 (Haas 1996), while in Japan and Russia the average academic was over 50 years of age (Arimoto 1996). Read together with female academics' concentration in the lower academic ranks (which is also evident in the results of the research by Boshoff (2005), referred to above) and their smaller average number of years spent in the academic profession, the South African results point to the effect of affirmative action policies with regard to the recruitment and appointment of academic members of staff in recent years.

Conclusion

The data used in this study indicate a steady increase in the research output of female academic members of staff at UZ in the periods in question. This increase was mainly achieved as a result of an increase in the percentage of females employed. The increase may not, necessarily, be solely attributable to an increase in the "per person" research output of female academics, which still lags behind that of their male counterparts.

From the results we may conclude that some headway has been made in wiping out the gender disparities in terms of research output, however, the bulk of research output continues to be produced by male members of the academic staff. This suggests that attempts to empower women researchers may not be entirely adequate. More needs to be done to support their research activities.

Alternatively, a different approach may be required to afford them their rightful place alongside their male counterparts. Focusing on support to assist female

academics to obtain doctorates might well prove to be a profitable strategy, as it may help to ameliorate the problem alluded to above. On the one hand it will contribute to raising the research output of female academic members of staff. On the other hand, given the importance of a reputable publication record for promotion in the academic profession, it will also elevate female academics through the “glass ceiling” in the academic profession – a problem not only limited to South Africa. The comparative study by Wollhuter *et al.* (2003/2004) furthermore suggests that the New Zealand experience of training their academic and research members of staff in research management *per se*, may, in South Africa’s case, be a model that is worth emulating.

Recommendations

It is clear that in order to achieve gender equity in research output, it is not only necessary to employ more female academic members of staff. It is also necessary to attempt to employ more highly qualified female academic members of staff. Alternatively, some higher education institutions may consider it a profitable exercise to invest in staff development programmes that are aimed at assisting academic members of staff with the attainment of doctoral degrees.

Attempts to appoint and promote more female academics in the higher academic ranks (senior lecturer, associate professor and full professor) will depend on their increased research output. Promotion through these higher academic ranks depends to a large degree on the quantity as well as the quality of research output. The increase in the research output of female academic members of staff is therefore not a goal in itself, but rather a *conditio sine qua non* for the equalisation of gender representivity in the higher academic ranks.

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